EAST AFRICA HIGH COMMISSION

EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANISATION

(Incorporating the East African Agricultural Research Institute, Amani)

ANNUAL REPORT 1951

Postal Address: P.O. Box 21, Kikuyu, Kenya

PUBLISHED BY AUTHORITY

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Staff List as at 31st December, 1951

(Including Officers of the Clove Research Scheme, the Climatic Data, Termites, and Ecology Schemes)

DIRECTOR

B. A. Keen, D.Sc., F.Inst.P., F.R.S.

DEPUTY DIRECTOR

H. H. Storey, C.M.G., M.A., Ph.D., F.R.S.
(On Vacation Leave — 30th June, 1951)

RESEARCH OFFICERS

H. F. Birch, Ph.D.	*Soil Chemistry*
G. T. Chamberlain	*Spectrography*
L. R. Doughty, B.Sc. (Agric.), N.D.A.	*i/c Fertiliser Scheme*
D. W. Duthie, M.A., Ph.D., F.R.I.C.	*Assistant to Director* *Editor, E.A. Agricultural Journal*
J. C. M. Gardner, C.I.E., A.R.C.S., D.I.C., Dip. For. *(Assumed duty October,* 1951)	*Entomology*
G. H. Gethin Jones, M.Sc.	*Soil Survey*
J. Glover, M.Sc., M.I. Biol.	*Plant Physiology*
P. J. Greenway, O.B.E., F.L.S. *(Vacation Leave April-September,* 1951)	*Systematic Botany*
A. L. Griffith, O.B.E., M.A., D.Sc.	*Forestry*
P. R. Hesse, B.Sc., A.R.I.C.	*Soil Chemistry*
D. L. Jennings, B.Sc.	*Plant Breeding*
K. S. McKinlay, B.Sc.	*Entomology*
R. F. W. Nichols *(Deceased 26th June,* 1951)	*Plant Pathology*
F. J. Nutman, D.Sc., D.I.C. *(Seconded as Director, Clove Research Scheme)*	*Plant Physiology*
P. Robinson, B.A., Dip. Stat. *(Vacation Leave December,* 1951)	*Statistics*

D. Rudd Jones, M.A., Ph.D., M.I. Biol. — *Plant Pathology*

R. M. Scott, B.Sc. — *Soil Survey*
(*Embarked U.K.* 29-12-51)

Miss F. M. L. Sheffield, D.Sc. — *Cytology*
(*Returned from Secondment to Clove Research Scheme October,* 1951)

B. Verdcourt, B.Sc. — *Systematic Botany*
(*Vacation Leave October,* 1951)

Scientific Assistants

Miss A. L. Alexander, B.Sc. — *General Analysis*
(*Vacation Leave, pending retirement, December,* 1951)

Miss D. M. Cooper, Dip. Agr. — *General Analysis*
(*Seconded Clove Research Scheme February,* 1951. *Vacation Leave December,* 1951).

W. B. May, F.R.H.S. — *Horticulture*
(*Returned from Secondment Clove Research Scheme January,* 1951)

Miss M. Maclean, B.Sc. — *Spectrography*
(*Assumed duty December,* 1951)

Mrs. A. K. Ryland, B.Sc. — *Plant Pathology*
(*Returned from Vacation Leave October,* 1951)

Miss E. Smith, B.Sc. — *Spectrography*
(*Vacation Leave, pending retirement, August,* 1951)

Count A. E. Staryenski — *Systematic Botany*

Field and Farm Staff

D. W. Gourlay, B.A. (Agric.) — *Field Experimentalist*
(*Vacation Leave November,* 1951)

H. P. Ledger, N.D.D. — *Farm Manager*

T. Graham — *Field Assistant*
(*Returned from Vacation Leave January,* 1951)

P. H. Hosegood — *Field Assistant*
(*Vacation Leave November,* 1951)

T. E. C. Robins — *Field Assistant*
(*Seconded Clove Research Scheme September,* 1951)

Mrs. W. Griffith — *Clerical Assistant*
(*Assumed duty January*, 1951)

Mrs. J. M. Lee — *Clerical Assistant*
(*Assumed duty January*, 1951.
Resigned June, 1951)

L. C. Martin, M.B.E. — *Maintenance Superintendent*
(*Vacation Leave June-July*, 1951)
(*Returned after Secondment to E.A.R. & H. July*, 1951)

Mrs. P. C. Martin — *Clerical Assistant*
(*Resigned January*, 1951)

T. Matthews, T.D. — *Secretary*

Miss J. Nutman — *Clerical Assistant*
(*Returned to Clove Research Scheme after Secondment April*, 1951)

Mrs. F. K. O'Hagan — *Clerical Assistant*
(*Resigned November*, 1951)

Miss J. Ossent, M.A. — *Research Librarian*

J. D. Roberts — *Assistant Maintenance Superintendent*
(*Vacation Leave February-September*, 1951)

Mrs. M. F. Skipper — *Registry Clerk*
(*Assumed duty March*, 1951)

Mrs. D. M. Smith — *Business Manager, E.A. Agricultural Journal*
(*Resigned 31st December*, 1951)

Miss M. A. E. Vardy — *Private Secretary to Director*
(*Returned from Vacation Leave July*, 1951)

S. G. Walter — *Assistant Accountant*
(*Returned from Vacation Leave June*, 1951)

A. F. S. Warwick — *Storekeeper*
(*Assumed duty January*, 1951)

Mrs. I. M. Warwick — *Clerical Assistant*
(*Assumed duty March*, 1951)

Under Colonial Development and Welfare Schemes Administered by the Organisation

W. V Harris, M.Sc., A.I.C.T.A., M.I. Biol. (*Returned from Vacation Leave June*, 1951)	*Termite Research*
Miss P. B. Kemp, M.A.	*Termite Research*
W. A. Sands, B.Sc., A.R.C.S., D.I.C. (*Assumed duty September*, 1951)	*Termite Research*
C. G. Trapnell, O.B.E., B.A.	*Ecological Training*
A. Walter, O.B.E.	*Agricultural Meteorology*

Clove Research Scheme

Miss F. M. Roberts, Ph.D. (*Seconded from Rothamsted Experimental Station*)	*Plant Pathology*
M. J. Way, B.A. (*Seconded from Rothamsted Experimental Station*)	*Entomology*
Miss J. L. Smith (*Resigned September*, 1951)	*Scientific Assistant*

REPORT BY THE DIRECTOR

(I) Introduction

Construction at Muguga was far enough advanced by March, 1951, for the transfer of staff, equipment and library from Amani to be started. The move has been a lengthy affair; indeed it will not be completed until early in 1952. The experience gained in the move of the Herbarium (Annual Report, 1950, p. 14) was of value in carefully planning this larger move so that interruption of work would be a minimum, but serious dislocation was unavoidable. Transport facilities were meagre, and the 25 miles of mountainous road between Amani and Muhesa railway station limited each lorry load to a few stoutly constructed and carefully packed boxes. The Railway authorities were quite unable to allocate to us more than one truck to run between Muhesa and Kikuyu. The abnormal and heavy 'long rains' caused major breaks on the railway, and compelled the authorities to divert our truck for a while to other tasks, which caused further disorganisation of our own time-table. In these circumstances we were especially grateful to Messrs. Karimi Tea Estates for the loan of a lock-up godown at Muhesa railway station.

It is unnecessary to set out the carefully devised programme for the movement of staff and material of all kinds, and the intricate balancing of many conflicting priorities. It is sufficient to state that in spite of the unforeseen additional delays due to the weather conditions, all the essential items of the scientific equipment were in working order in the new laboratories in time for the official opening at the end of May, and there were hardly any breakages or losses in transit. This achievement reflects great credit on all concerned, especially on Mr. Greenwood, Engineer, Amani, who constructed special packing cases and generally supervised a complicated time-table of packing and despatching.

Besides the interruption of work directly due to the move, there were other lengthy delays—notably in the biological programmes—because of the non-arrival of material ordered from home; glasshouse equipment is one example. Difficulties of this kind are the consequence of the abnormal home, shipping and local conditions, and we, unfortunately experience their cumulative effect: for example, by the time gas is available in the laboratories, the delivery and erection of the gas plant will have occupied over three years from the date of ordering.

(II) The Opening Ceremony

The Rt. Hon. Mr. James Griffiths, P.C., M.P., who was then Secretary of State for the Colonies, opened the Station on the 26th May, 1951, during his visit to East Africa. The Governor of Kenya, H.E. Sir Philip Mitchell, G.C.M.G., M.C., in his capacity as Chairman of the East Africa High Commission, presided over a gathering of some 400 guests from Kenya, Tanganyika, Uganda and Zanzibar.

In the proceedings, reference was made to the generous action of the Kenya Government in giving the East Africa High Commission some 1,600 acres of the Muguga Forest Reserve for the Headquarters of E.A.A.F.R.O. Goodwill gifts were also announced from the Government of Tanganyika, who gave mninga wood for library furniture; the Government of Uganda, who supplied mahogany and muhimbi for panelling and flooring the Conference Room; and His Highness's Government, Zanzibar, who gave an inkstand for use with the Visitors Book. An indication of the wide interest aroused by the proceedings was the arrival of cables of good wishes from the following: H.E. the British Resident, Zanzibar; Agricultural Research Council of Great Britain; Rothamsted Experimental Station, England; Rowett Research Institute, Bucksburn, Aberdeenshire, Scotland; Empire Cotton Growing Corporation; Overseas Food Corporation; Waite Agricultural Research Institute, Adelaide, Southern Australia; Cawthron Institute, Nelson, New Zealand; Scientific Council for Africa South of the Sahara; and the Carnegie Corporation of New York (who, 20 years ago, endowed the library).

In the laboratories a comprehensive display was assembled to show the research activities in progress at out-stations as well as at Muguga. The work of Colonial Development and Welfare Schemes that are attached to E.A.A.F.R.O. and integrated with its own research programme, was also displayed. The range of all these activities was of obvious interest to the Secretary of State and the guests, many of whom were not hitherto aware of the variety of inter-territorial problems already under examination, or of the frequent use made by the E.A.A.F.R.O. staff of suitable out-stations for these purposes.

It is, therefore, appropriate in this section of the Report to give a list of the exhibits in summarised form, to serve as a record of the work already in progress, and its bearing on both territorial and inter-territorial problems:—

(a) *Fertility Status of Tropical and Sub-Tropical Soils.*—This is a major priority in the programme. Several Sections are directly or indirectly connected with it. (i) Field experiments. A team has operated for three seasons on over one hundred sites in East Africa. The exhibit showed for various crops, and soils, the effect on yield due to the addition of nitrogen and phosphorus fertilisers—the Uganda phosphate deposits being included in the latter. (ii) Laboratory experiments. Soil and crop samples from the experiments provide material for basic research on tropical soil fertility. This exhibit showed a most promising method of measuring in the laboratory the need of a soil for phosphate fertiliser and its probable response. (iii) Plant physiology. This is parallel work to (ii), but done on the plant under controlled conditions to study its nutritional requirements. The exhibit showed the importance of proper balance between the nitrogen and phosphorus supply to the plant: any excess of either is wasted. (iv) Soil survey and land utilisation. Examples were shown of the methods of survey and the results. The sorting out of various soil types enables the results of the field

experiments to be properly grouped for advisory purposes; this is, however, only one incidental object of its main tasks —the scientific grouping of soils into classes, and the practical recommendations on the best agricultural utilisation of each class. (v) Ecology and land survey. This is the task of one of the attached C.D. & W. Schemes, whose purpose is to train men for the range of ecological duties in the Colonial Empire. Its scope is, therefore, a wide one, and fertility status problems are only one of its aspects. In this sense it is the vegetational complement to the soil aspects of land classification. (vi) General agricultural analysis. These are necessary in large numbers. For soils alone, 15 separate determinations on each of 1,500 soils have been done since the field experiments mentioned above were begun. Modern spectrographic methods have speeded up the work, and will also be used, when suitable apparatus arrives, for examining suspected trace element deficiencies.

(b) *The Moisture Status of Tropical and Sub-Tropical Soils.*—This is also of high priority, and, under the general name of soil physics, has intimate associations with hydrology and meteorology. The aim is to establish a balance sheet between rainfall, run-off, evaporation, transpiration and percolation. The exhibit showed the measurement of rainfall penetration into soils of varying structure and surface conditions, and the factors controlling the storage of moisture in the soil and its availability within the root range of crops. An attached C.D. & W. Scheme is working on the assessment of the meteorological factors concerned.

(c) *Control of Plant Diseases.*—This is another major priority in the programme. The exhibits mostly dealt with the indirect control of disease by breeding resistant or immune varieties. (i) Cassava (*Manihot utilissima*), is an important food reserve crop, that is seriously affected by two virus diseases, Mosaic and Brown Streak. Cross-pollenation of cassava with related and resistant species over a number of years at Amani has produced highly resistant plants. As these are woody, back crossing with cassava is now in progress: it is hoped to produce resistant varieties that are both high-yielding and palatable. (ii) Maize is affected by Streak, a virus disease. The breeding of resistant varieties is in progress, together with basic research work on the mechanism of transmission of the virus from a diseased plant, through the body of the vector insect—a leaf hopper—to a healthy plant. (iii) Rosette disease of groundnuts is also a virus disease prevalent in almost every groundnut area of Africa. The vector insect is a common black aphid. The disease is carried over by 'volunteer' plants that grow from nuts left behind in the soil at harvest; removal of volunteers is a hopeful control measure. It is known that closer spacing of groundnuts reduces the amount of Rosette: the reason for this has not yet been found.

(d) *Forestry Investigations.*—This Division of E.A.A.F.R.O. had only recently been formed. It was, however, able to show the beginning of experimental work on forest nursery techniques. In addition, two of the plant pathology researches falling in (c) above were exhibited: the study of a serious fungus disease of cypresses, and a root and butt rot of forest trees. The former is a matter of some concern, because of the large areas planted to soft woods and the high susceptibility of the popular *Cupressus macrocarpa* to the disease. The latter fungus attacks both exotic and indigenous species, and may also cause damage in plantations, e.g., tea plantations, by spreading from the stumps of indigenous trees in which it can persist for many years. A forest entomology exhibit was also provided to illustrate some of the problems in this new field.

(e) *Clove and Coconut Diseases.*—This exhibit was provided by the C.D. & W. Clove Research Scheme, Zanzibar, which is directed by a seconded E.A.A.F.R.O. Officer. It showed (i) the cause and control of 'die-back' of cloves, which produces heavy losses, although the disease is less spectacular than 'sudden death'; (ii) the suspected cause of 'sudden death' and the means of control if, as now appears very probable, the disease is due to a fungus and not a virus as originally thought. But the most striking exhibit of all was the one showing how the research work on insects apparently associated with the clove diseases led, quite unexpectedly, to the discovery of the cause of the widespread and damaging 'Gumming' disease of coconuts. This unexpected development was of great interest to the visitors, for it was an admirable example of the point stressed in previous Annual Reports, that the organisation of a research station must be flexible, and so must its declared programme, if full practical advantage is to be secured from research.

(f) *The East African Herbarium.*—The exhibit showed the routine and research work of the Herbarium: identification of material; collection and ecological surveys; revision and re-classification of species; preparation of floras and check lists.

(g) *Statistical Research.*—Examples were shown, (i) of the design of laboratory and field experiments that would give the maximum amount of reliable information from the experiment, and (ii) sampling surveys, in which results of a small sample can be used to infer the answer for the whole material, e.g., transect surveys through a forest to find the amount of economically important timber.

(h) *Colonial Termite Research.*—This is an attached C.D. & W. Scheme for the period of its work in East Africa. The exhibit showed the various kinds of termites—mound builders, subterranean, etc., and their effects. In an associated exhibit the Chemistry Section, E.A.A.F.R.O., showed research work on the chemical and physical characteristics of large mounds.

(III) Description of Headquarters

In earlier Reports only a brief statement of the progress in construction made during that year has been given. It is therefore appropriate, in the present Report, to give a connected account of the development of Muguga from a wattle and eucalyptus plantation into a research and residential area.

The E.A.A.F.R.O. estate is the Southern portion of the Muguga Forest Reserve and lies about 14 miles north of Nairobi close to a main trunk road. It is undulating land except for one large flat area on which the headquarters and laboratories have been built. It lies between 6,500 and 6,900 above sea level, and has an average rainfall of 36.52 inches, most of which falls in two periods—the 'long' and 'short' rains. (See Table on page 23.) Because of the altitude and the moderate rainfall the usual difficulties of laboratory work in the tropics do not arise; the one exception is the dust from the murram roads in the dry windy season and this will have to be countered by providing a tar-mac surface.

The C.D. & W. Scheme provided a capital grant of £296,000 wholly given by the British Government, who contribute under another C.D. & W. Scheme one-half of the recurrent costs as well. The remaining half of the recurrent costs are shared equally between Kenya, Tanganyika and Uganda, and Zanzibar also provides a small contribution.

Much of the capital was necessarily devoted to purposes other than laboratories, library, and other service buildings. Large quantities of wattle had to be felled and the land stumped. An access road three miles long together with internal estate roads had to be constructed. Houses for European, Asian and African staffs had to be planned and built. Economies in the total housing costs were effected by providing a number of cottages grouped around a central club building, for housing junior and unmarried members of the European staff. Two boreholes, a large reservoir and a reticulated water-supply system had to be built, a gas-plant erected and electricity brought to the site. In fact, nearly 54% of the total capital was absorbed by these items, leaving just under £135,000 for direct expenditure on the Research Organisation, as follows:—

	£
Laboratories	34,300
Library	13,000
Offices, Bureaux, etc.	21,100
Site works for above items	4,700
Workshops, stores, etc.	5,200
Equipment, scientific and general ...	42,300
Animal Industry Division	14,300
	£134,900

Because of the economy in construction and efficiency in joint research that would be secured by a close association with the sister

organisation—the East African Veterinary Research Organisation—the C.D. & W. Scheme for the above work was drawn up with that end in view. Thus, the library, workshop, stores are common to both Organisations; the Animal Industry Division is a joint one; one-quarter of the laboratory area is for veterinary and joint Animal Industry research; and the administrative headquarters are under one roof.

The laboratories are of single-storey design, in three blocks. Each block consists of six laboratories 15′ x 20′ separated by a corridor from six ancillary laboratories 15′ x 12′, the latter being sub-divided where necessary into rooms 7½′ x 12′, which is a convenient size for balance rooms, dark rooms, chemical stores, offices, etc. None of the transverse walls carries any load, so that redivision of laboratories, if needed later, will not require major structural alterations. Benches are of unit-design, and steel-furniture is standard. The bench tops were not imported from England but made from mvuli (*Chlorophora excelsa*) a hard wood, that came from the Amani plantations. The total costs for benches were much reduced by this, and further economies were made by making floor blocks from the off-cuts and waste pieces.

There is ample space on the axial line of each laboratory block for the orderly and convenient placing of service buildings such as storage and preparation rooms, glasshouses, etc. The laboratories themselves were also built to an over-all plan that provides space for an extension to at least double their present area, together with their additional ranges of service buildings, should such extensions be needed. It should be noted that one small extension of the laboratories on this over-all plan has already been made, to provide space for the attached C.D. & W. Scheme for ecology training (see page 85).

The library was built up at Amani into one of the best agricultural and scientific collections in Africa. This task was facilitated by the endowment given some long time ago by the Carnegie Corporation of New York. Its usefulness will be increased by the incorporation of the books and journals on the veterinary sciences, and by the greater facilities for consultation by visitors that Muguga affords, as compared with the isolation of Amani. Special thought was, therefore, given to the design of the building to meet modern requirements. The building has a cork floor, and consists of six large bays, facing a large central space where there is adequate area for an attendant's desk and card-index cabinets, racks for current periodicals, map-storage drawers and reading tables. In each of the bays there is room for 1,000 foot run of shelves: the total run of 6,000 ft. will house the books without crowding for some years ahead. The bays are also large enough to house one or two small reading tables and chairs. The maximum shelf height is 7 ft. so no book is beyond arm's reach. The windows are ingeniously disposed so that there is adequate diffuse daylight illumination in the bays throughout the day, with little or no direct sunlight. Finally, at one end of the library there are four small rooms fitted up as study cubicles for those writing reports and theses. The librarian's working room and office, the library dispatch and bookbinding room, and the stack room for

reprints and little-used volumes, are in the general administration building, and immediately adjoin the library entrance.

The functions of the general administration building housing the offices, bureaux, etc., are best described by giving a list of the rooms it contains, and their uses. Besides the three rooms serving the library and mentioned in the preceding paragraph, provision is made for the following: The head of the Forestry Division of E.A.A.F.R.O. and the Forestry Bureau that has been set up at the request of the territories; the head of the Statistical Section of E.A.A.F.R.O. and his computing staff; the head of the Joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O.; the headquarters of the Interafrican Bureau of Epizootic Diseases; a large conference room 39′ x 20′ (with an ante-room) which will be used for scientific discussions, meetings of Advisory Bodies, etc.; finally there are the offices for the Directors and administrative staffs of E.A.A.F.R.O. and E.A.V.R.O. which, together, occupy less than half the total floor space of the building.

The capital expenditure on the joint Animal Industry Division is divided between development costs for the farm area, such as clearing, fencing, paddocking, farm roads and the erection of the ranges of farm and field-laboratory buildings needed for the scientific and ancillary farm operations of the Division. These include a farm office, Dutch barn, implement sheds, animal houses, pens, and yards (some being designed for normal farm work, others for nutrition experiments) and a set of laboratories for metabolism experiments. All the construction work has been placed in charge of Mr. Martin, the Maintenance Superintendent, who by using our workshop facilities and employing direct labour, is able to show very substantial economies over normal contract prices. As an indication, the seven roof trusses for the Dutch barn, each 34′ span, and the uprights, 20′ above ground, were welded from lengths of secondhand steel pipes condemned as no longer satisfactory for carrying water, but amply strong enough for trusses.

For over-riding reasons the erection of the Animal Industry buildings had to be deferred until the end of 1951, but the bulk of them should be completed and in use by the middle of 1952.

(IV) Machinery for Organising Research

Reference was made in the 1950 Report to attempts to simplify cumbrous administrative and financial procedures. The new Research Organisations Committee has met approximately quarterly during 1951. From the necessarily limited experience to date it appears that it will serve a useful purpose until a permanent solution on the lines of a Governing Body is possible.

The interlocking arrangements of cross-representation on scientific committees has continued. During the year the Tea Research Institute of East Africa was created and under its constitution the Director, E.A.A.F.R.O., is *ex officio* the Chairman of its Board of Governors, and the Director of the Tea Research Institute has been appointed a member of the East African Advisory Council on Agriculture, Animal Industry and Forestry.

Dr. Storey attended the meeting of the Scientific Council for Africa South of the Sahara that was held at Dakar, French West Africa. Dr. Griffith attended the Inter-African Forestry Conference held at Abidjan which was organised by the French Government under the auspices of the Commission for Technical Co-operation in Africa South of the Sahara.

An important step was taken by the Advisory Council at its meeting in January, 1951, when it endorsed the Director's proposal that members of E.A.A.F.R.O. scientific staff should undertake advisory visits to territories outside East Africa, and any associated laboratory work, provided that the Director was satisfied that corresponding benefits to the E.A.A.F.R.O. research programme would arise from the visit or laboratory work, and that all travelling and other costs were met by the government or body concerned. During the year the following visits were made or planned under this arrangement.

Dr. Griffith toured the forest areas of Southern and Northern Rhodesia, and advised the former Government on forestry research priorities. Mr. Gethin Jones accompanied for a period the Central African rail link and development survey party to advise on soil survey problems, and visited Nyasaland in connection with the Shire Valley Development Scheme. Mr. Trapnell also accompanied the rail link party to advise on ecological aspects and discussed in Nyasaland the development and land reclamation plans in the Nyika plateau and Zomba areas respectively. The Director has accepted an invitation from the Sudan Government to become a member of their Advisory Committee on Agricultural Research and to pay an annual visit of inspection.

It is appropriate in this section of the Report to mention that arrangements were made under the Fulbright Act of the U.S.A. for a year's attachment to E.A.A.F.R.O. of Dr. C. R. Hursh, who is Chief of the Division of Forest Influences in the U.S. Forest Service, and a recognised authority on forest hydrology. Dr. Hursh arrives early in 1952; his period in East Africa should be of great assistance to us in planning our researches, as well as to the territories.

Two new specialist committees dealing respectively with genetics and plant breeding, and crop insecticides have met during the year.

Arrangements with O.F.C.

During 1951, Mr. Gillett, Chairman of the Overseas Food Corporation, put forward an important proposal for a closer association between the scientific staff and programmes of E.A.A.F.R.O. and O.F.C. The proposal was for a separation of the basic and applied (or agronomical) research in the O.F.C., the former being made the responsibility of E.A.A.F.R.O., and the latter remaining under the O.F.C. To this end it was proposed that four members of the O.F.C. scientific staff should be attached to the appropriate sections of E.A.A.F.R.O., and that their programmes of research should be closely integrated with those of the E.A.A.F.R.O. sections. The four O.F.C. members would continue to work in the Tanganyika

centres, and O.F.C. would meet their salaries and other charges. The arrangement would continue until March, 1953, when it would have to be reviewed in the light of the then financial situation. After discussion this proposal was gladly accepted. Its effect is to offset to a large extent the reduction in certain items of the research programme of E.A.A.F.R.O. due to rising costs and reduced staff. Satisfactory arrangements have also been made to ensure close contact between all the E.A.A.F.R.O. basic research and the O.F.C. technological investigations. The O.F.C. officers and the respective research sections concerned are: B. Anderson, B.Sc., Soil Survey; A. C. Evans, Ph.D., Entomology; Ir. F. Hagenzieker, Soil Chemistry; A. R. Wood, B.Sc., Soil Physics.

(V) E.A.A.F.R.O. and the Public

As E.A.A.F.R.O. was built and is maintained by public funds supplied by the British and East African Governments it is necessary that all reasonable means should be employed to keep the public informed of the objects and work of the Organisation. Visits to the station are welcomed, especially if notice is given beforehand, and a member of the staff will be available to act as guide. During the period June-December, 1951, and excluding the 400 present at the official opening, over 200 visitors have been to Muguga. They include organised parties such as Administrative Cadets, and African Chiefs who were attending courses at the Jeannes School, Kabete, and the Annual Conference of Science Teachers.

Articles of a more general or popular appeal than the specialist research papers published in the scientific journals have not been overlooked. In the weekly and daily journals articles have been published on appropriate occasions dealing with the use of statistical methods on the farm, on tree diseases and pests, and on the way in which research work into one problem sometimes provides a totally unexpected solution for another and different problem, as has recently happened in Zanzibar, where research into clove tree diseases suddenly uncovered the cause of the 'gumming' disease of coconuts and the method of controlling it. Other articles dealing with topical matters and with subjects of general interest will be published from time to time.

(VI) Scientific Work of the Organisation

The discussion of the past year's scientific activities must begin by drawing the conclusion from the coconut work done by the Clove Research Team, Zanzibar. Details of the investigation and how it arose will be found on page 44. The point to be stressed here is that if public funds given specifically for research are to be efficiently used, then the Research Organisation must be able to make suitable changes in its declared programme when the need arises, and the administrative and financial procedures must be flexible enough for the change to be smoothly and quickly made. In the present instance there were, fortunately, special circumstances that enabled this to be done. A further relevant remark must also be made. The need for

major divergencies from declared research programmes arises much more often that is generally realised. In addition, less important and minor changes are the rule rather than the exception. In fact, the only investigations that usually produce results in accordance with prediction are those of a routine nature; such investigations have only a subsidiary and incidental place in the programme of a Research Organisation.

The present report contains four more Section Reports than last year: Plant Breeding and Genetics, Insecticides, Soil Physics, and Soil Survey, and other sections give accounts of additional work. This is a measure of the staff appointments made during the past 18 months, and it offsets to some extent the reduction in research work due to the transfer from Amani. For this last reason there will be less for comment this year in one of the major priorities of our long-range programme: the fertility status of tropical and sub-tropical soils, but substantial advances have nevertheless been made. These are discussed immediately below under the headings of Field and Laboratory Experiments.

(a) The Fertility Status of Tropical and Sub-Tropical Soils

Field Experiments

As recorded in Mr. Doughty's Sectional Report (page 56), E.A.A.F.R.O. took responsibility for the experiments for a further season so as to maintain continuity between the previous three years' work of the Fertiliser Scheme, and the future experiments under Territorial Departments of Agriculture auspices. The team's activities were not directly handicapped by the move from Amani, but the field staff was less than before and, in addition, some members had to spend considerable time at Amani to maintain the cassava work when Mr. Nichols died. In these circumstances the preparation and planting of 71 major and 71 minor field experiments and the harvesting of 57 and 55 respectively was a creditable achievement. The whole of the four years' results are now being closely re-examined and, with the completed results of the closely associated Highland Fertiliser Scheme of the Kenya Department of Agriculture, are being prepared for discussion and report in 1952 by the Specialist Committee on fertiliser responses. It is expected that definitive recommendations will arise from that report, and it will be sufficient now to give a brief statement only of the indications of the 1951 experiments, that supplement the account of the previous three seasons results (see Report, 1950, p. 9).

In the wetter districts the sedentary soils derived from granites respond to nitrogenous fertilisers, and, when eroded, usually to phosphate as well. Both nitrogen and phosphate responses are given by red earths derived from basement complex rocks and gneïss (N.E. of N. Nyanza, Kenya), and especially large phosphate responses but insignificant nitrogen responses are given by soils lying on or derived from sediments and acid volcanic deposits.

In the dryer areas similar responses to those shown in wetter districts are given by granitic soils. The semi-arid laterised red earths show phosphate responses.

In the sandy coastal belt soils, some of the few cases of response to potash in East Africa have been observed; as would be expected nitrogen and phosphate are both needed.

Laboratory Experiments

These are complementary to the fertiliser experiments discussed above, and deal with the equally important matters of the effect of soil type, climatic factors and various crops on the nutritional responses. The laboratory work of the Soil Chemistry, Soil Survey, Plant Physiology and Statistical Sections is directed to these ends and forms part of the concerted attack on that major research priority: the fertility status of tropical and sub-tropical soils.

Dr. Birch's demonstration that an easily measured soil property (the percentage saturation of the base-exchange-capacity) is much more closely related to the response of that soil to phosphate manuring than are the previous methods of assessing phosphate status, has now been extended to the analyses of plant samples from the fertiliser trials. It is found that the amount of phosphate in the crop is highly and directly related to the degree of saturation of the base-exchange-capacity of the soil. The evidence for the range of acid soils in East Africa is thus practically complete and will now be rounded off by developing a method for measuring the amount of base-linked phosphate in acid soils, for it appears that the phosphate held in that way is available to the plant, while the phosphate associated with the clay colloid is much less available.

Mr. Gethin Jones is handicapped by lack of staff in his soil survey investigations. He has, therefore, devoted much time to making plans, in close co-operation with the territories, for surveys of land-use, that can be employed for immediate practical problems such as area development, anti-erosion measures, etc. He has also given detailed attention to the soils on which the Fertiliser Scheme experiments—E.A.A.F.R.O. and the Kenya Department of Agriculture—were done, so that they shall be classified and distinguished among themselves, even though final classification in an over-all survey scheme is not immediately possible.

Other co-ordinated work on this main priority of fertility status, has been held up in various degrees. Very substantial progress has been made, however, in the use of the spectrographic technique by Mr. Chamberlain. Reference to his Report (page 65) shows that several thousand analyses have been done on the Fertiliser Scheme soils, and that other bodies such as the Sisal Research Station and the Overseas Food Corporation have been assisted and advised. Similar remarks apply to the General Analysis Laboratory. The Plant Physiological Section, however, was unable to continue fully with its nutritional studies, because of the transfer from Amani, but there was time to secure some confirmation of the continued uptake of phosphorus by the plant in quantities that increase with the amount supplied, even when growth is severely restricted by limiting the nitrogen supply.

(b) Other Soil Researches

The Effect of Termites

Mr. Hesse is studying the large mounds in Tanganyika, which exert influences, sometimes good, sometimes bad, on the growth of crops. The physical and chemical properties of the soil in the mound differ systematically from the soil in the vicinity; the increased clay content in the mound is easily understandable, but the increased calcium content, often in nodular form, is more difficult to understand because there is some evidence that it only occurs after the mound is abandoned.

Soil Physics

Although this Section cannot be formed till 1952 it was possible for some work to be done in 1951 thanks to the agreement with the Kenya Department of Agriculture and the Coffee Research Station, Ruiru, by which, pending his transfer to E.A.A.F.R.O., Dr. Pereira was able to give part of his time to soil physics research problems. By arrangement with the Director of Agriculture, Kenya, a brief account of this work is included in the present Report (see page 67). The soil physics work is an important part of our programme as it will elucidate problems of soil structure that bear on the creation of a tilth suitable for tropical soils. It is not fully recognised either by farmers or their advisers that the now well-proved need for inducing a crumb structure in temperate climate soils is still an open question in tropical and sub-tropical soils. A closely associated soil physics problem deals with the water-balance in our soils, and this in turn is closely linked to some aspects of meteorological measurements that are under study in a separate C.D. & W. Scheme (see page 87).

Soil Microbiology

No work on this most important aspect of fertility status has yet been possible; but, during the year, arrangements were made with the Rothamsted Experimental Station for a year's secondment of an experienced officer in this subject, who will conduct a survey into certain problems of known importance, pending the creation of a Soil Microbiology Section. It is hoped to form this Section in 1953, and the arrangement with Rothamsted will bridge the gap and save valuable time.

(c) Plant Pathology

Crop Diseases

The dislocation due to the move, the death of Mr. Nichols and the absence of two members on vacation leave, have slowed up the work The breeding work on cassava has been taken over by the new Genetical Section, and Mr. Nichols' records were found to be so complete that the continuity of the work is assured. Trials continue of the back-crosses to cassava of the hybrids between cassava and related species resistant to mosaic and brown streak, in the attempt to combine resistance with good yield and palatability.

The main work on virus disease of groundnuts has been the differentiation in the field-symptoms of various viruses, or distinguishable strains, which range from that giving the severe stunting and uniform leaf chlorosis of typical rosette, to two others that produce only a mild mottle. In co-operation with Dr. Evans of the O.F.C., Dr. Storey has begun to test whether legumes other than groundnuts will carry over the virus to the following season; in addition, the bionomics of the aphid vector of rosette is under investigation. Work also continues on the collection of wild species of *Arachis* to see whether any are immune to the virus and if so, whether they can be used as a source of hybrids.

The study of streak disease of maize in the attempt to produce resistant varieties has been reopened after an enforced lapse of some years and fortunately it has been found that much of the stored seeds were still viable.

The return of Dr. Sheffield—towards the end of 1951—from secondment to the Clove Research Scheme enabled the suspected virus disease of sweet potatoes to be examined. A preliminary tour to Uganda and the Belgian Congo has disclosed that the spread of the disease is determined by height above sea level, and it is possible that this reflects the climatic preference of an insect vector.

Work has begun on the bud disease of pyrethrum at the request of the Pyrethrum Board of Kenya. It is being done in collaboration with the Kenya Department of Agriculture who are concentrating on the mycological aspects, while the Plant Physiology Section of E.A.A.F.R.O. is attacking the physiological and climatic problems. It is already evident that a damp cool climate encourages the fungus, and there are further suggestions that the eco-climate, i.e., the climate within the clump, is important, possibly more so than the macro-climate over the field. The buds are produced within the clump and if they develop and set within the shelter of the clump and not on stalks above it they are more likely to be attacked by the fungus. This work is a good example of the value of an inter-territorial research organisation that has available experienced research officers for tasks of this kind. It was not necessary for the Board to go to the expense (and the difficulty) of engaging a research worker for a term, but only to provide the relatively small amount needed for an extra scientific assistant to help in the laboratory, glasshouse and field work.

Forest Pathology

Dr. Rudd Jones has made substantial progress in his study of the canker disease of cypresses in all of the three sections of this work: studies of the fungus in culture, the degree of resistance to canker, and general field and survey work. The differences between the various strains, in rate and habit of growth, viability, etc., have been further elucidated. The technique developed for comparing the resistance of Cupressus species and allied genera has been intensively used, while the survey studies have included examinations of the relation between tree age and susceptibility to the disease, and the effect on this relation of thinning the plantation.

Experiments on other tree diseases, such as *Armillaria* root rot, have continued. The rapid fungal-rot deterioration of both imported and locally built wooden craft on Lake Victoria has also been examined.

(d) General Forestry Research

Most satisfactory progress was made by Dr. Griffith during 1951, in close consultation with the Conservators of Forests and their specialist officers. The programme for E.A.A.F.R.O. for a number of years ahead is now completely agreed, and an appreciable proportion of it has already been started. This is exclusive of the E.A.A.F.R.O. research in forest pathology that is grouped under Plant Pathology (see immediately above, and also page 31) and the recent appointment —by transfer from the Kenya Forestry Department—of an experienced forest entomologist. With the arrival of a second silviculturist the forestry part of our programme can now make rapid progress. Reference to Dr. Griffith's Report (page 45) shows that silviculture problems predominate in the present stage of forestry development in East Africa, and further, that the immediate needs of the territories are more for information and technological studies than for basic research. The E.A.A.F.R.O. programme has been drawn up, therefore, to meet this situation. It gives prominence to the collection and distribution of existing information through the medium of a Forestry Bureau and to a number of immediate problems arising from the increasing planting of soft woods, such as improvements in nursery techniques and in planting out (on which Mr. May has already given much help); and finally, to the elucidation of the best cropping cycle for short-term tree crops, taking into account total yields, and possible deterioration in either the soil, or in the number and vigour of the regenerating stools. Meanwhile, basic research has been started to sort out the consequences of the extensive hybridisation that has already taken place in soft wood species.

Attention is also being given to problems of enumeration—or stocktaking—and to the systematic collection of tree measurements to provide yield tables. Finally the difficult problem of the regeneration of hard woods is to be tackled, as none of the present natural or artificial means is satisfactory.

(e) Clove Research

Dr. Nutman and his team have some striking matters to report, one of which is of great significance in its bearing on the efficient conduct of research.

The Cause of Die-back

Conclusive proof was obtained in 1951 that 'die-back'—the crippling and economically important but rarely fatal disease of mature clove trees—is caused by a fungal wound-parasite. The fungus is a new species of *Cryptosporella*. The majority of the wounds that allow entry to the fungus are caused at picking time, when many

small and even large branches are splintered or broken off. More care in picking, together with normal measures of estate hygiene such as clean pruning or sawing of broken branches and protective painting would reduce die-back to insignificant proportions. The effect of these measures has been demonstrated by Dr. Nutman, who took some extreme cases of die-back necessitating drastic tree-surgery on main boughs and trunk to remove all wood infected by the inward travel of the fungus. In each case the trees have, so far, not only survived but are growing healthily. *Cryptosporella*, in addition to causing die-back in mature trees, has now been shown to cause the death of young clove trees as well. Hitherto these deaths, that closely resemble the manner in which mature trees die of Sudden-death, were taken to indicate, in default of other explanation, that Sudden-death was becoming even more virulent and extending its ravages into younger and younger age-groups.

Sudden-death of Cloves

The demonstration that the die-back fungus is in all probability responsible for deaths of young trees, removes yet one more piece of the formidable circumstantial evidence that Sudden-death was a virus disease. Sustained efforts, totalling more than 5,500 experiments, employing every known method of mechanical inoculation and grafting, and using twelve possible insect vectors, have not produced any positive evidence of a virus. Meanwhile the possibility of a fungal pathogen, discounted by previous investigators, was reopened with striking results. A fungus, now shown to be a new species of *Valsa* is invariably associated with Sudden-death. Its behaviour, from the early to final stages of the disease, fits closely the symptoms observed in the tree. Further, the behaviour of the fungus after the death of the tree and, in particular, the subsequent appearance of fructifications on the trunk, is not only in accord with the observed manner of spread of Sudden-death, but also suggests a feasible method of arresting that spread.

'Gumming' Disease of Coconuts

The cause of this hitherto obscure disease, which gives rise to extensive losses of nuts on the mainland as well as in Zanzibar and Pemba, has been discovered by the work of the Clove Research Scheme. It is due to a coreid bug, a species of *Theraptus*, whose nymphs and adults puncture the female flowers and fruits, completely destroying those that are at an early stage of development, while those attacked later, usually produce dwarf distorted nuts with scar-like lesions from which oozes the gummy material that gives the disease its name. The discovery was made during investigations of the habits of an ant (*Oecophylla longinoda*) that builds many nests in clove trees. The ant was under suspicion of being associated with the Sudden-death disease of cloves. It was found that it also built nests in the trees of coconut groves, especially those adjoining clove plantations. Immediately a remarkable correlation became apparent: trees containing the ants' nests bore heavy crops of large healthy nuts, while trees with no nests had, almost invariably, either no crop or a few small gummy nuts of no value as copra. Further search disclosed that the bug was the culprit, and that the trees were protected by the ants because they were predators on the bug.

Pending arrangements by the Zanzibar Government to appoint full-time workers, the staff of the Clove Research Scheme concentrated their activities on this important problem. The possibilities of biological control by the ant, or of direct insecticidal control were explored. As the annual value of the present coconut crop in Zanzibar and Pemba alone is about £1,000,000, and as the value of the crop from one good tree is about Shs. 5/-, there is clearly a good margin for expensive remedial measures even if they gave only partial control of *Theraptus*. In experimental control measures a ten-fold increase of crop was obtained.

The wider significance of this quite unexpected development has already been discussed (pages 13 and 14). The research that uncovered the cause of gumming disease and the methods of control, was undertaken with quite other objectives, and there was not the remotest idea in anyone's mind that it would end where it did.

(f) Other Research Activities

Insecticides

The study of crop insecticide problems was one of the agreed items in the original E.A.A.F.R.O. programme but it soon became evident that neither funds nor staff would be available for the full programme. Only one officer was recruited and by arrangement with the Empire Cotton Growing Corporation he was stationed at the new Cotton Research Station, Namulonge, Uganda, where he was able to work in close collaboration with the staff and also maintain contact with the Uganda Department of Agriculture. Thanks are due to those concerned, and especially to the E.C.G.C. for providing for a period, house and laboratory accommodation for Mr. McKinlay.

During the year a concerted programme of an exploratory nature was started in order to pick out those problems of a basic nature that were also relevant to tropical conditions. The formation of a Specialist Committee on insecticides ensures that the E.A.A.F.R.O. programme will be drawn up with due regard to all the other insecticide work in progress in East Africa.

Plant Breeding

This section was reconstituted towards the end of the year and its research programme was formulated after a meeting of the Specialist Committee on plant breeding. Mr. Doughty will be in charge, assisted by Mr. Jennings. To begin with, the programme will take over the breeding of cassava, maize and groundnuts, and will also work on the genetical factors concerned in the resistance of sorghum to the parasitic weed *Striga*. The breeding results in the cassava work will also be genetically examined.

The East African Herbarium

The Herbarium has completed its first full year in its new and accessible quarters in the grounds of the Coryndon Museum, Nairobi, and is able to report that the number of visitors using the collections has greatly increased. Collections have been received, loaned and

named, and the usual exchange of duplicates has been continued. Amalgamation of the Amani and Coryndon Herbaria has proceeded, and further type specimens have been found and described.

Statistics

Examination of the extensive records of the E.A.A.F.R.O. and Kenya Fertiliser Schemes and of the associated laboratory data, was continued. Among the enquiries for statistical assistance may be mentioned the following: (a) an examination of sampling technique used to determine transit losses of pyrethrum during export; (b) experiments for testing the efficiency of insecticides; and (c) the design of experiments for testing herbicides and, in particular, the devising of suitable measurement procedures for weeds with ramifying habits, like couch grass. Investigations are also in progress on rainfall prediction and on determining the degree of reliability of rainfall in marginal areas.

Joint Animal Industry Division

Satisfactory progress was made during 1951, in clearing and planting operations. A wide variety of crops and fodders was planted and useful knowledge gained on their cultivation and other requirements. A number of the harvested crops have been put for trial into pit silos. The range of observations made this year will be continued in the future, to build up a complete agronomic picture of farming advantages and hazards in this climate and altitude. The general characteristics of our average local rainfall are shown in Table on page 23 together with the figures for 1951. It will be noted that the main feature of the abnormal rainfall of this year was not so much the increased amount as the much greater increase in the number of rainy days. The excellent growing season, therefore, was due more to the frequency of rain than to the increased amount.

(g) C.D. & W. Schemes Attached to E.A.A.F.R.O.

Termite Research Scheme

With the arrival of Mr. Sands the team is complete, and Mr. Harris' programme is now in full swing. Miss Kemp continued her work in Tanganyika, and Mr. Harris has widened the area of study to Aden and the Somaliland Protectorate.

Ecology Training Scheme

As the first two students will not finish their post-graduate training at Oxford until the middle of 1952, Mr. Trapnell will not be able to begin his training programme until about September, 1952. During 1951 he has been making a number of reconnaissance surveys in East Africa to find useful training areas. He has discussed with the territorial departments their needs in ecological surveys, and also spent some time with the development survey party at work on the Central African rail link.

The laboratories built for this Scheme were completed and equipped for air photograph studies, mapping work and the handling of field material.

Climatic Data in Relation to Agriculture

Mr. Walter has continued in England his testing of the formula for the indirect measurement of radiation from simple meteorological elements. The formula was constructed from East African data and its applicability is now being tested with the much longer run of records available at Kew Observatory, England.

(VII) Staff

The tragic death of Mr. R. F. W. Nichols in a car accident at Amani was deeply regretted by all his colleagues. He had served Amani with devotion for 20 years and the best tribute to his memory is Dr. Storey's description on page 26 of the completeness of the experimental records of the work in Nichols' charge.

Recruitment to vacancies has proceeded only slowly, and has been offset to some extent by resignations, especially of Scientific and Clerical Assistants. During the year the following have resigned: Scientific Assistants: Miss Alexander (General Analysis) and Miss E. Smith (Spectrography). Clerical Assistants: Mrs. Lee, Mrs. O'Hagan, Mrs. Martin and Mrs. D. Smith. Storekeeper: Mr. D. Smith. In addition, the following were seconded from E.A.A.F.R.O. to the Clove Research Scheme, Zanzibar: Miss Cooper (Scientific Assistant) and Mr. Robins (Agricultural Assistant).

Recruitments to the staff effected or arranged during 1951 included the following: Research Officers: Mr. Gardner (Forest Entomology), Dr. Pereira (Soil Physics), Mr. Sands (Termite Research Scheme), Mr. Scott (Soil Survey) and Mr. Stuart (Silviculture). Scientific Assistant: Miss Maclean (Spectrography). Clerical Assistants: Mrs. Griffith, Mrs. Skipper and Mrs. Warwick. Storekeeper: Mr. Warwick. In addition, Dr. Sheffield (Plant Pathology) and Mr. May (Horticulture) returned from secondment to the Clove Research Scheme.

The delay in implementing the new Colonial Research Service, whose inauguration as from January 1st, 1949, was announced by the Secretary of State for the Colonies on January 31st, 1950, is affecting the retention of existing staff, especially those younger members who were appointed on the understanding that they would be transferred to the new Service. One special feature of the Colonial Research Service was to be the equivalence of salary scales with the British Scientific Service, so that, with appropriate allowances to offset differences in living costs, transfers and loans of workers between home and the colonies and between colonies could be made without difficulty. Although this arrangement has not so far come into effect it is satisfactory to record that the Rothamsted Experimental Station, England, found it possible to second Dr. Roberts and Mr. Way to the Clove Research Scheme, to agree that Dr. Meiklejohn shall spend a year with E.A.A.F.R.O. to study soil microbiology problems and, in addition, to spare Dr. Gregory for a brief visit to examine the bud disease of pyrethrum. Thanks are due to Rothamsted for all this help and co-operation.

Publications:

Keen, B. A., (1951). *The East African Agriculture and Forestry Research Organisation: Its Origin and Objects.* (East African Standard Ltd.)

Keen, B.A., (1951). *The East African Agriculture and Forestry Research Organisation. Nature,* **168**, 674.

Table of Muguga Rainfall

Numerator: Ins. rain.

Denominator: No. of rainy days.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Average	1.09 / 2	1.73 / 3	3.88 / 8	8.67 / 16	8.13 / 14	1.46 / 5	0.53 / 1	0.69 / 2	1.11 / 2	1.98 / 6	3.97 / 9	3.28 / 7	36.52 (for 33 years) / 75 (for 18 years)
Average Running Total	1.09 / 2	2.82 / 5	6.70 / 13	15.37 / 29	23.50 / 43	24.96 / 48	25.49 / 49	26.18 / 51	27.29 / 53	29.27 / 59	33.24 / 68	36.52 / 75	
1951	3.18 / 6	0.14 / 2	3.08 / 11	16.87 / 27	7.91 / 26	5.87 / 10	0.41 / 4	1.13 / 8	0.25 / 3	4.65 / 14	6.28 / 14	7.77 / 19	57.54 (58% over normal) / 144 (92% over normal)
1951 Running Total .	3.18 / 6	3.32 / 8	6.40 / 19	23.27 / 46	31.18 / 72	37.05 / 82	37.46 / 86	38.59 / 94	38.84 / 97	43.49 / 111	49.77 / 125	57.54 / 144	

Library

STAFF

Miss J. Ossent ..... *Research Librarian*

Library services were reduced practically to a standstill during the main part of the year so as to make preparations prior to packing. It was possible, however, to complete certain assignments, such as the compilation of the catalogue for the periodical sets (rough copy) and a revised list of current periodicals with descriptive data on exchange or subscription conditions and publications.

A small consignment of books was transferred to Muguga at the very beginning of the year so as to meet the requirements of the Chemical and Statistical Sections.

The main job of packing the library was started in July and was completed in October. A total of 230 packing cases was filled and railed to Kenya in three instalments. The moving of large furniture and bookbinding machinery is still delayed because no adequate truck is available as yet. The library books, wrapped and packed by the joint efforts of the bookbinding and library staff, arrived in excellent condition.

The librarian moved to Muguga at the beginning of October and, thanks to the help of the scientific staff in unpacking and checking, all books were installed on their appropriate shelves by the end of November. The full restoration of library facilities will take some time, because only local and untrained African staff are available. It is hoped that the situation will improve in the coming year.

The new library provides sufficient room to meet our requirements for some time ahead, as well as space for the E.A.V.R.O. library which is to be absorbed during the course of 1952.

Because of its more accessible situation near the city of Nairobi, it is expected that visitors from East Africa and other places will be increasing and that scientific workers at large will be able to make full use of our facilities. The Muguga library, which incorporates the libraries of the former Amani Research Institute and the Biologisch-Landwirtschaftliches Institut of German East Africa, offers extensive collections of periodicals and books in almost every agricultural and scientific subject. Many of them have become unique due to the devastation of libraries in Europe during the last World War.

East African Agricultural Journal

STAFF

D. W. Duthie ..... *Editor*
Mrs. D. Smith ..... *Business Manager*

Mrs. Smith resigned with effect from the 31st December, 1951, and it is a pleasure to record great appreciation of her work for the Journal during the past two years.

As mentioned in the Report for 1950, it was found necessary to raise the annual subscription from Shs. 5/- to Shs. 10/- as from Volume XVII, No. 1, July, 1951. The full effect of this cannot be judged until all subscriptions have fallen due for renewal, but the latest available figures show that the number of subscribers has dropped from approximately 1,500 in 1950 to 1,200 in 1951. Nearly 400 of these subscriptions are due for renewal, so there may be a further drop in the total. The distribution of subscribers is: Kenya, 426; Tanganyika, 215; Uganda, 125; other countries, 435.

In spite of the increase in subscription, difficulty is being experienced in balancing revenue from subscribers and advertisers with expenditure on printing and postage, since costs of publication and distribution are still rising, and are likely to continue to do so. During the past eighteen months the salary of the Business Manager was paid from E.A.A.F.R.O. funds, and as no salary is paid to the Editor as such, the Journal has been produced without any overhead expenses. But E.A.A.F.R.O. cannot continue to carry the salary of the Business Manager, and thus the financial position is critical and the future of the Journal is uncertain. A further increase in the annual subscription would almost certainly cause a further drop in the number of subscribers.

In view of the position consideration has been given to the "market value" of the Journal. It is, and always has been, midway between a farm journal and a specialised scientific journal. It serves, therefore, a purpose that is not met by any other publication in East Africa and by few outside. Technical officers of the East African territories and the High Commission are the main contributors, and their papers provide a valuable record of investigations which have been carried out in East Africa: there is no doubt that the Journal has always been a technical success, and the subscription list shows that it is appreciated in over seventy countries and dependencies besides British East Africa. The Journal was never intended to be a practical farm paper, as this market is catered for by commercial interests. However, it should be noted than an appreciable number of farmers interested in the technical problems of agriculture are subscribers. It must be concluded that if it is to maintain its present character — and there are very strong arguments why it should — then it must continue to be subsidised.

SECTIONAL REPORTS

Plant Pathology

STAFF

H. H. Storey ..... *Deputy Director*
Dr. F. M. L. Sheffield ..... *Plant Pathologist*
R. F. W. Nichols ..... *Plant Pathologist*
D. Rudd Jones ..... *Plant Pathologist*
Mrs. A. K. Ryland ..... *Scientific Assistant*

The work of a research unit in biology inevitably suffers dislocation during a move of site. This has been especially true of the Plant

Pathological Division, the research of which is largely concerned with growing plants and living insects, requiring elaborate equipment and materials, glasshouses and other special buildings. By the end of the year re-establishment of the work was beginning to take place at Muguga, with the completion of some of the glasshouses and ancillary buildings.

Fortunately this period of enforced check in research coincided with the vacation leave of two members of the staff, Dr. H. H. Storey and Mrs. Ryland, who were consequently absent for some six months each; while Dr. Sheffield returned from secondment to the Clove Research Scheme, Zanzibar, only in the last quarter. In these circumstances only limited progress can be reported in virus research.

But the Division has suffered its severest blow in the loss of Mr. R. F. W. Nichols, who died in a motor accident on the 26th June. Nichols had been closely associated with the Amani virus research since 1929, and indeed before that, since he first joined Storey in South Africa in research of which the Amani work was in part a continuation. His main work in recent years had been in breeding cassavas for resistance to virus diseases, which, it can reasonably be hoped, is on the threshold of producing great changes in cassava-production in East Africa. Although lacking any University degree, Nichols' outstanding service had caused the Secretary of State to accept him for admission to the new Colonial Research Service. East Africa and E.A.A.F.R.O. have lost much by his death at an age when his powers to contribute to research were at their height.

Dr. Rudd Jones has continued his research in forest pathology throughout the year. At the beginning of October, Dr. F. M. L. Sheffield, on return from secondment, began research on the virus diseases of Sweet potato. Reports by these officers follow.

Virus Diseases of Cassava

H. H. Storey and L. R. Doughty

By the death of Mr. R. F. W. Nichols, E.A.A.F.R.O. lost a research worker whose special knowledge of cassava and its breeding will be difficult to replace. He had taken an important part in all the early research at Amani on cassava virus diseases and in the programme of breeding for resistance initiated in 1937; for the past six years he had been solely responsible for the policy in breeding and for its execution.

The dislocation in the cassava programme has, however, not been as severe as might have been expected. The large bulk of data from years of crossing and experiments had been recorded in such a clear and orderly manner that it has been possible to pick up the threads of the work with little difficulty. We have lost Nichols' intimate knowledge of all the hybrid material and plans that were in his mind but not committed to paper; but the admirable consistency of his records has permitted a continuation of the work without serious break. Nevertheless progress will inevitably be slowed down until we can acquire, by practical experience, some of the lost knowledge.

It has been decided that this breeding work should pass to the control of the newly established Genetical Section under Mr. L. R. Doughty. On Nichols' death, Doughty visited Amani and took over control; Mr. W. B. May and Mr. T. Graham were posted from other work to continue the work at Amani under Doughty's direction. These two officers were able to maintain the recording and to complete the harvesting of current experiments and to take control of the maintenance plots, as well as to raise hybrid seedlings from all the seed resulting from controlled pollinations carried out by Nichols early in 1951.

Progress during the year is reported in the following sections:—

Hybrids.—The 1950-51 crossing programme was an extensive one and comprised back-crosses of hybrids of Ceara origin to cassava for a second, third and fourth generation, in an endeavour to improve yield whilst still retaining resistance to mosaic. Also back-crosses of *Manihot dichotoma* hybrids for a second or third generation and similar back-crosses with hybrids of Tree cassava origin. From these crosses some 2,900 seedlings have been raised.

From the 34 successful crosses made in the 1949-50 season some 180 clones have been planted in a preliminary resistance trial at the Sisal Experimental Station, Ngomeni.

Field Trials.—Trials conducted during the past season included five major resistance trials and one preliminary elimination trial, this last comprising the remainder of the material from the 1947-48 crop of seedlings. The season has been favourable and in consequence the crop has been very satisfactory.

Of the 300 clones in the replicated resistance trials there appear to be fewer clones free from mosaic throughout the trial period amongst the third back-cross generation than amongst the second. This applies equally to material with *Manihot glaziovii*, Ceara, or *M. dichotoma* in its ancestry, although there is a big proportion in both generations that remain free from mosaic for most of the season, succumbing to attack only in the later periods of recording. From the point of view of yield, the third back-cross generation of Ceara origin is more promising than that incorporating *dichotoma*, although some clones of the latter have given reasonable yields after eleven to twelve months in the field.

Few of the hybrids, *M. melanobasis* x cassava, have shown resistance to mosaic in the preliminary elimination trial, but yields of root are again high in comparison with those of other clones in the trial; also symptoms of Brown streak disease are rare in this series of hybrids.

Yield Trials.—During the year the harvest has been completed of the experiment comparing the yield of a standard variety of cassava, *Msitu*, with that of an apparently mosaic-tolerant hybrid of Ceara origin, No. 4332/2. The plots harvested were those for digging after eighteen months and after two years in the field. This experiment has suffered severely from drought in the early stages; and mosaic had spread in the early months to all plants originating from healthy cuttings.

In total yields, combining those for all periods of harvesting, there is no appreciable difference between the yields of the two varieties where healthy, mosaic-free cuttings were planted, nor is there much difference in yield between the 12, 18 and 24 months periods in the ground. Where diseased cuttings were planted, however, the yield given by the hybrid 4332/2 was about double that obtained from *Msitu* and the yield of the hybrid at the later harvests was not very different from that obtained by planting healthy cuttings, confirming a considerable measure of tolerance of the disease in the hybrid.

Future Policy.—With the resuscitation of a Plant Breeding and Genetics Section of the Organisation the work on cassava breeding will be continued on the same lines; but in addition the vast amount of data collected over past years is being examined from a genetical point of view, a task that has not been possible to date.

Virus Diseases of Groundnuts

H. H. Storey and A. K. Ryland

Research on the relation between the aphis vector and the rosette virus of groundnuts was continued at Amani in the early part of the year, until circumstances already mentioned enforced a temporary closing down of experiments. The work done was mainly confirmation and extension of results reported in earlier Annual Reports; and no new evidence of importance emerged from it. It is planned to re-open this line of study early in 1952 at Muguga.

During late 1950 and early 1951 we started to study strains of rosette virus that occur in the field. Various workers have noted, both in East and West Africa, variations in the symptoms observed on groundnuts in the field. As already reported, investigations at Amani showed that two viruses, apparently distinct in so far as a uniform difference in their symptoms may be accepted as reliable, can produce a mild mottle in groundnuts. The type of symptom, and the fact that *Aphis craccivora* has always failed to transmit either virus in our experiments, caused us tentatively to regard these two viruses as not closely related to rosette virus. Within the group of diseases regarded as rosette, however, variations in symptom-expression are commonly found in the field. The most striking are, in the first place, the "typical" rosette, characterised by a uniform, or nearly uniform chlorosis of the leaves and very severe stunting, and, secondly, the so-called "mosaic-rosette," where chlorosis is confined to sharply defined areas of the leaflets, and stunting is markedly less severe. By various experimental techniques we have extracted strains of virus (or mixtures of strains) producing uniformly distinct symptoms in experimental plants. These strains are transmissible by *Aphis craccivora*, which fact suggests that they are closely related. Work has been started on the interaction of the strains within the plant but has not been advanced sufficiently to allow of firm conclusions.

A limited number of experiments was carried out on transmitting the rosette virus to species of legumes other than groundnut. No transmission was recorded in any of these. This is a line of work that we hope to extend greatly in 1952. It evidently has an important bearing on the possibility that the rosette virus may survive the off-season, in areas such as Southern Tanganyika, in perennial wild plants. We plan to co-operate in this with Dr. A. C. Evans, Overseas Food Corporation, who, as mentioned below, is engaged on field studies on rosette at Nachingwea.

We have also carried out experiments in transmitting the rosette virus to the collection of wild *Arachis* spp. that has been introduced from overseas. Evidence shows that some of these are susceptible, although there is an indication, not yet fully confirmed, that some may be immune. The value is evident of an immune species, as a starting point for an interspecific-hybridisation programme, if successful crossing can be achieved. In due course, when we have full information on the behaviour of these *Arachis* spp., material will be transferred to the Genetical Section.

During 1951 three interim reports on the progress of the Amani groundnut research were prepared and circulated to the O.F.C. and to others interested.

Experiments carried out at the Kizugu Sub-Station, ten miles from Amani, aimed mainly at studying the manner of secondary spread of rosette under field conditions. In earlier reports we have referred to our conception of two phases in rosette-spread in the field; the primary phase, due, as we suppose, to winged aphids entering the field from outside; and the secondary phase, due to short-distance movement of aphids from the diseased plants, infected during the primary phase, to other plants within the field. Conditions at Kizugu during our experiments were such that, on the evidence obtained, there was little or no spontaneous primary infection. We were thus able to place diseased, and aphis-infected, plants at chosen points within otherwise uniform healthy groundnut plots, and so to study the spread of rosette resulting from the presence of these diseased plants. One point that emerged from these experiments was that the wingless aphids, as well as the winged, played an important part in spreading the virus; a water barrier, uncrossable by the wingless aphids, but not of course hindering movement of winged aphids, markedly reduced the amount of spread without preventing it completely.

In previous reports we have referred to the need to study the bionomics of *Aphis craccivora*, if we are to obtain a full understanding of the manner in which rosette invades and spreads in groundnut fields. It is satisfactory, therefore, to be able to report that, through the co-operation of the Overseas Food Corporation, Dr. A. C. Evans is now engaged on these desirable studies at Nachingwea, in collaboration with E.A.A.F.R.O. Interesting and suggestive conclusions are emerging from his work, which will be reported in due course.

Mr. J. D. Jameson and Mr. D. G. Thomas, of the Uganda Department of Agriculture, carried out in 1951 further field trials on

rosette spread at Serere. This year's results, which in general confirm previous conclusions on the effect of close spacing mentioned in earlier E.A.A.F.R.O. Reports, will be reported in their Department's Annual Report.

Streak Disease of Maize

D. L. Jennings

The work of breeding maize resistant to the streak virus was reopened in December, 1950. Much of the seed that had been stored since 1940 proved to be viable. Samples of seed from 34 out of 50 families tested showed a range of germination of from 5% to 50% and it has thus been possible to re-establish many of the inbred lines of the original resistant Peruvian maize as well as some of the Durum hybrids derived from it.

Using the intensive testing system evolved by Dr. Storey it was found that many plants appeared to be immune from the disease, while in others the resistance took the form of an enhanced power of recovery.

During the year the opportunity was also taken of studying the occurrence of the disease in parts of the Lake Province, Tanganyika. Several of the native maize varieties were found to exhibit a variable reaction to the virus and it was possible to make selections of apparently resistant plants for further testing.

A Suspected Virus Disease of Sweet Potatoes

F. M. L. Sheffield

In 1944, an epidemic of what was apparently a virus disease of the mosaic type caused considerable alarm in East Africa. The disease had been present in the Belgian Congo at least since 1939 and was thought to be spreading eastwards from there. However, it was soon recorded in even the eastern parts of Tanganyika. Both Nichols, at Amani, and Nattrass, at the Scott Laboratories, were able to transmit the disease by grafting. In 1944, many white fly were seen on the crop but experiments by Nichols to use it as a vector failed.

In November, 1951, as a preliminary to a more fundamental study of the disease, I made by road a 3,000-mile tour in order to see the disease in the field. The tour included Uganda, Ruanda-Urundi and much of the mountainous eastern part of the Belgian Congo. The diseased plants showed a great range of symptoms including stunting and reduction in leaf size, leaf distortion or reduction to a strap-shape, back-rolling of the margins, toughening of the leaves, vein-clearing in the younger leaves, mottling and a bronze mottling of the lower leaves. Within any one variety, in any one locality, the symptoms were usually uniform except for differences in severity. It was assumed that the severe forms were primary infections and the milder ones, secondary. There was no evidence to suggest whether the disease is due to one virus or to a complex.

Over 50 plots, planted by Europeans or Africans, were examined in detail. These were at varying altitudes and it became apparent that, in the areas visited, the amount of spread of disease within the crop varies at different heights. Between 4,000 ft. and 5,500 ft. above sea level, it is very great; above 6,000 ft., it is slight; and between 2,000 ft. and 3,500 ft., there is no spread, even if the disease has been introduced there. No land below 2,000 ft. was visited. It is probable that the disease is transmitted by an insect and it is possible that this cannot exist in the climatic conditions occurring at low altitudes and that its breeding or mobility is restricted at high altitudes.

In an attempt to find a vector of the disease, most of the plots visited were searched for sucking insects. The most prevalent were white fly and jassids, but these were present even when there was no spread of the disease. A little thrips-damage was seen but only one specimen was found. Three or four species of coccids were seen, but two were localised whilst another was ubiquitous but was never present in very great numbers. *Helopeltis* damage was widespread but usually very slight and these insects were actually seen on Sweet potato only once. One aphid was found whose distribution agrees very well with that of the disease. It was never numerous but was widespread in plots where disease spread was greatest; it was confined to isolated groups of plants at high altitudes and was never found at low altitudes.

Two other symptoms which might be due to viruses were seen. One was an uprolling of the leaves and the other a hairiness of the stems, petioles and laminae. Both were sometimes combined with mosaic symptoms and both occurred at all altitudes but neither appeared to be of serious importance.

The tour was made to the territories chosen because the mosaic-type disease was said to be more serious there and also with the object of visiting those officers who had had most experience of it. The variation in the amount of spread at different altitudes was an unexpected result and may be of considerable importance. It is obvious that, in the areas visited, when material is being propagated for distribution to farmers or for variety trials at other Experimental Stations, it should whenever possible, be grown at low or high altitudes and be vigorously rogued. The general impression is that the disease is less serious in Kenya and Tanganyika. It is possible that it has not yet fully invaded these territories or that little attempt is made to grow Sweet potatoes at the critical levels, or that the vector finds other host plants which it prefers. An attempt will shortly be made to gain information on this point.

Forest Pathology

D. Rudd Jones

During 1951, although the investigation of canker disease of cypresses still had the major place, the progress already made enabled more attention to be given to other problems.

Canker Disease of Cypresses Caused by Monochaetia unicornis

The report on canker disease is divided, as before, into three sections dealing respectively with field and survey work, degree of resistance to the disease, and studies of the fungus in culture.

Field Investigations and Survey.—During February and March an extensive tour was made through the forests of Uganda and the disease was confirmed on *Cupressus macrocarpa* at Kabale near the Belgian Congo border. Only Strain B was present. (Report, 1950, page 27.)

The recording of sample plots has provided information on the parts of the tree most commonly infected. In unpruned, strip-by-strip plantations of *Cupressus macrocarpa* and *C. lusitanica*, three years old, 90.0 per cent of the diseased trees had been infected in branch crotches and of these, 58.0 per cent had two or more canker lesions, 8.5 per cent had cankers on other parts of the branch than at the crotch, some of these in addition to crotch cankers, 6.0 per cent had cankers on the stem and 2.5 per cent had been infected at the collar. The percentage recovery (i.e., occluding of cankers) was 6.0 per cent for *C. macrocarpa* and 10.5 per cent for *C. lusitanica*. In once-pruned, pure plantations of the two species, five and six years old, 44.0 per cent of the trees had been infected in branch crotches, and 66.0 per cent on stems, 10.0 per cent of these also having crotch cankers. Infections on the stem were frequently localised on branch scars or in pruning wounds; 22.5 per cent of the trees also had branch cankers other than at the crotch. The percentage recovery was 32.5 for *C. macrocarpa* and 86.5 for *C. lusitanica*.

Trees are most susceptible to the disease two to three years after planting and the number of new infections falls by the time trees are five years old, only then occurring in the actively growing leaders or branches, though stem cankers may be initiated through pruning scars or wounds. Cankers in the older parts of a tree normally show good recovery. Plots have been set up to determine what effect thinning of plantations will have on development of the disease. It is possible that a slower growth rate, as a result of competition, may account for part of the difference in susceptibility between the various age classes.

Further studies have been made on the distribution of the different strains of *Monochaetia unicornis*. In a plantation at Bahati Forest, Strain A was isolated both from conidia and from ascospores of the perfect stage on the same tree (Nattrass, R.M., (1950), *Ann. Rept. Dept. Agric., Kenya*, for 1948, p. 95). Other trees in the plantation yielded Strain B in conidial isolations and the two strains never appeared together on isolation plates from the same tree. Strain A was also present in other plantations at Bahati although only Strain B had been present when the area was first visited in 1949.

Two collections of the fungus have been made from the E.A. Pencil Cedar (*Juniperus procera*). One of the collections corresponds to Strain A, but the other is new and has been named Strain D. (Strain C is a sterile, non-pathogenic strain which has arisen in

culture). Strain D produces a mild lesion on *Juniperus procera* but is non-pathogenic on all *Cupressus* species tested. The presence of this strain on an indigenous conifer would strengthen the theory of the evolution of a serious parasite from a comparatively harmless fungus (Nattrass, R. M., and Cicarrone, A., (1947), *Emp. For. Rev.*, **26**, p. 289).

Experiments carried out on the movement of conidia indicate that, at the period of maximum production during misty weather, they fall rapidly after liberation, in sticky masses, although a few spores were caught at a distance of 100 metres from an infected plantation. Conidia retain their viability for fairly long periods (see below) and it is possible that "long-distance" spreads occur during the dry season when conidia dry out and separate from the mass. Infection might then take place during the following rains. Ascospores may be the agents of long-distance spread since they are smaller than conidia, but they also adhere together in sticky masses on liberation.

A search was made for perithecia of the perfect stage in natural and artificially produced cankers. In 72 natural cankers, all over six months old, perithecia were found in ten, normally interspersed with acervuli, but, in two specimens, present over a large area beyond the first-formed acervuli. In 275 artificially inoculated cankers, also all over six months old, perithecia were present in twelve, in every case except one interspersed with the first-formed acervuli close to the inoculation wound. In the one exception they were also present among the second crop of acervuli 30 mm. to 50 mm. from the point of inoculation. Although the numbers are too small to be significant there was an indication that some collections are more likely to form perithecia than others.

Perithecia have been produced in culture, in one instance only, on a sterilised twig.

Registance and Susceptibility of Cupressus Species and Allied Genera.—During the year only three new infections have been recorded in sample plots containing five hundred trees of *C. lusitanica* in the Mt. Kenya area (Report, 1950, page 26), but in the 1948 strip-by-strip plantation of the two species at S. Kinangop, the percentage infection has arisen to 94.5 in *C. macrocarpa* and 53.5 in *C. lusitanica*.

Using a standard wound through the bark, followed by the placing of a standard agar inoculum over the wound, the resistance of five *Cupressus* species has been investigated. The most rapid longitudinal extension of cankers was in *C. benthami*, with *C. macrocarpa*, *C. arizonica*, *C. lusitanica* and *C. torulosa* following in that order. If inoculation was delayed for four days after wounding the order was, *C. benthami*, *C. macrocarpa*, *C. lusitanica*, *C. arizonica* and *C. torulosa*, and this is also the order of height growth of the five species. With inoculation further delayed after wounding, the number of successful inoculations fell, *C. macrocarpa* being most frequently infected. Under very wet conditions the numbers for *C. benthami* and *C. lusitanica* also remained high since the suberisation-barrier, formed following wounding, was readily penetrated by fungal hyphae. Further experiments along these lines are in progress.

The rate of healing of wounds has been examined in the five species. Suberisation and the initiation of wound periderm occurs about the same time in all five, being slowest in *C. torulosa*. Both suberised layers of cells and wound periderm can be penetrated by hyphae and, with the growth-flush of the host, the mycelium ramifies more rapidly in the newly formed wood than in the tissues of the cortex.

Further experiments on the growth of the fungus on bark and sapwood agars (Report, 1950, p. 27) of the five *Cupressus* species, *Juniperus procera* and *Podocarpus gracilior* (another indigenous conifer) gave very similar results. The bark of *Juniperus procera* promoted the best growth, both when made up on a fresh-weight and a dry-weight basis. The five *Cupressus* species gave slightly less growth, and growth was very limited and sparse on *Podocarpus gracilior* bark agar.

The water content of the bark of *Cupressus* species does not vary very greatly but there is a tendency for it to rise about two weeks after the start of the rains and to be lower in older bark. The barks of both *Juniperus procera* and *Podocarpus gracilior* have low water contents. The water content of the bark tissues has a profound effect on the growth of the fungus.

All the plots for testing for field resistance to the disease have been infected but results are not yet available.

Thuja orientalis, Cupressocyparis leylandii (*C. macrocarpa* X *C. nootkatensis*) and *Juniperus procera* have been successfully inoculated with Strains A and B. *Juniperus procera* has also been infected with Strain D. *Widdringtonia whytei* and *Podocarpus gracilior* were resistant to all strains.

Investigations on Monochaetia unicornis *in Culture.*—The collection of isolates has been increased to fifty-one, of which thirty-nine are Strain A, nine Strain B, two Strain C and one Strain D. Growth rate studies have shown that, although there are small variations between collections of the same strain, the differences are much greater between strains, A growing the most rapidly and the growth of both C and D on agar being very sparse.

Similarly, in the germination of conidia there are variations between collections, and with conidia from different acervuli on the same canker there may be considerable variation both in percentage germination and rate of extension of germ tubes. Nevertheless, strain differences still remain distinct and Strain D is peculiar in that germination and germ tube extension are limited in a saturated atmosphere and proceed most rapidly at relative humidity of 97.5 per cent.

The germination of ascospores follows very closely that of Strain A conidia.

Viability tests with conidia have again shown differences between collections, but conidia of Strain A retain their viability, under laboratory conditions, for ten to twenty months as compared with six to fourteen months for conidia of Strain B.

Production of acervuli in culture on sterilised twigs was limited for both A and B strains at relative humidities below 96.1 per cent. Acervuli initials were formed at 89.9 per cent R.H. but they did not develop. Acervuli of Strain A were ripe after twelve days in a saturated atmosphere at room temperature (approximately 20° C.), those of Strain B after five to eight days, and Strain D after twenty-four days.

Armillaria Root-rot

Further examination of cypress plantations has revealed that the fungus enters a "butt-rot" phase, the cambium often being killed over small areas thus inducing the ingrowth of bark and wood. The butt-rot seldom extends more than four feet up the stem and trees are not often killed by the disease, although in one twenty-year-old plantation of *C. lusitanica*, 80 per cent of the trees were infected. *Armillaria* butt-rot has also been found in ten- and eleven-year-old plantations of *Pinus radiata* and *P. patula*.

Different levels of virulence of separate foci of infection have been noted in a small seven-year-old plantation of *P. radiata*. The effect of thinning on the spread of the disease in this plantation is being studied.

Heart-rots of Cypresses

Heart-rots, of both the "brown-rot" and the "white-rot" types, have been recorded from plantation areas in Kenya, and a number of fungi have been isolated which are being studied with the assistance of the Department of Scientific and Industrial Research, Forest Products Research Laboratory, Princes Risborough. *Polystictus versicolor* is the only pathogen to have been identified so far (confirmed by Miss Wakefield at Kew). It was found causing a profound white rot of *C. macrocarpa* which is in contrast with its behaviour in Europe where it occurs normally as a saprophyte.

Infection takes place either through pruning scars or through so-called "stem cracks." The latter are very deep longitudinal cracks of the stem which occur in many planting districts, but appear to be most serious where the rains are immediately followed by a very dry period and especially where trees are growing under exposed conditions. The cracks close up with the onset of the rains and are occluded so that it is difficult to determine, prior to felling, if a tree is affected.

The Kenya Forest Department are undertaking a five per cent survey of all softwood plantations being thinned and it is hoped that this will yield information on possible losses from heart-rots.

Fungal Deterioration of Timber on Lake Victoria

During June and July two tours were made to Lake Victoria to investigate fungal rot in wooden vessels, both imported craft and locally built dhows, yachts and canoes. Wooden piers, slipways, lake-side buildings, etc., were also examined. Samples of rotted wood were collected and are being investigated with assistance of the F.P.R.L., Prince Risborough. A number of fungi have been isolated, among them species of *Poria*.

A wide range of timbers both imported and indigenous are attacked and deteriorate very rapidly under the conditions of the Lake micro-climate. "Graveyard" tests are being designed, using both seasoned and unseasoned timbers coupled with preservative treatments, and they will be set up at three stations on the Lake.

Other Tree Diseases

Chlorosis of *Entandophragma angolense* in nursery beds in Uganda was shown to be non-pathogenic.

Two unidentified fungi were isolated from leaf spots on *Khaya anthotheca.*

An undescribed species of *Phomopsis* was found to be the cause of canker and die-back in *Cassia siamea* in Uganda. This fungus had previously been recorded by Dr. R. M. Nattrass.

An unidentified specie of *Polyporus* was found to be causing a very serious root-rot of *Cassia siamea* at Malya in Tanganyika.

Three-year-old *Pinus patula* was killed by *Helicobasidium compactum* at Kigogo, Tanganyika. The same fungus was found infecting four-year-old *Cupressus lusitanica* and *Acacia longifolia* in Kenya. Both trees were suffering severe root competition from Kikuyu grass (*Pennisetum clandestinum*).

An unidentified species of *Pestalotia* was isolated from cankerous lesions on *Pinus canariensis.*

Future Programme

It is intended that the research on canker disease shall be concluded this year with the exception of recording sample plots and field resistance trials, and the examination of new collections for new strains. Work will be continued on *Armillaria* root-rot and heart-rots.

Publication:

Storey, H. H., (1951). *Basic Research in Agriculture: A Brief History of Research at Amani,* 1928-1947. (East African Standard Ltd.)

Plant Breeding and Genetics

STAFF

L. R. Doughty ..... *Officer-in-Charge*
D. L. Jennings ..... *Plant Breeder*

This section is in process of regeneration. The proposed scheme of work was discussed recently at a meeting of the East African specialist committee on plant breeding with a view to integrating the work of E.A.A.F.R.O., with other work in progress in East Africa. As the section will most likely be staffed by two plant breeders only, the projected programme is mainly a continuation of the breeding

work that has, in the past, been carried on by the Pathology Section, breeding for resistance to virus diseases in cassava, maize and groundnuts. The only additional feature is an investigation of resistance of sorghum to attack by the parasitic weed *Striga hermonthica*, and the possibility of breeding types of sorghum resistant to infestation.

During the past year D. L. Jennings has been concerned with the revival of breeding work with maize for resistance to streak disease and a certain amount of work on groundnuts. These items are included in the Plant Pathology Report (pp. 28-30). In addition, he has spent some time working with the Botanist, Tanganyika Department of Agriculture, on sorghum breeding at the Ukiriguru Station, Mwanza. He has also paid a short visit to the Kenya Plant Breeding Station at Njoro, to see the work in progress on maize breeding. During the latter part of the year he has been stationed at Eldoret doing some preliminary work on *Striga* and latterly working through the records relating to disease resistance in cassava, with a view to genetical interpretation of the breeding results to date, to afford guidance in further work.

As no further work on *Agave* breeding is practicable the plant material at Amani has been handed over to the Senior Research Officer, Sisal Experimental Station, Ngomeni. He is arranging for material of the more interesting hybrids to be sent to the High Level Research Station in Kenya after adequate quarantine.

Crop Insecticides

STAFF

K. S. McKinlay ..... *Entomologist*

Pending the building up of a section or unit for insecticide and allied investigations it was decided that any work done by E.A.A.F.R.O. should be centred at the Empire Cotton Growing Corporation, Cotton Research Station, Namulonge, Uganda, in close association with their own research programme. The E.A.A.F.R.O. member of the team, therefore, arrived at Namulonge during December, 1950, and suffered the usual delays whilst settling in, engaging African staff and awaiting the arrival of equipment.

Since this was the first year of work the 1951 programme was designed to cover as wide a field as possible in order to get some idea of the problems involved in the use of insecticides under tropical conditions.

Methods of Insecticide Application

The delivery rates of nozzles to be used for spraying the cotton in the later part of the year were measured and a certain amount of work done in order to relate size and distribution of deposit to the method of application used.

In view of other more important problems which have arisen out of the year's work and the fact that this type of work is not specifically a tropical problem it is not intended to continue it next year.

Laboratory Tests of Insecticides

A limited number of laboratory test of insecticides, using *Dysdercus nigrofasciatus* as a test organism, were carried out during the year. In toxicity and speed of action BHC gave the best results. Dieldrin, DDT and Toxaphene followed in that order but all were markedly slower in action. These results were checked by a field trial late in the season in which BHC, DDT and Toxaphene sprays were compared. Once again BHC was very rapid in action and 80% of the fifth instar stainers seen on the BHC plots next day were dead. DDT was slower in action but after five days it was level with the BHC, both showing a mortality of about 80% to 90%. Toxaphene lagged very badly behind and at this time the mortality on these plots was only of the order of 40%. Recent comparisons of this Toxaphene wettable powder with a more recent sample make it seem likely that this first sample was a bad one and that Toxaphene properly formulated would be extremely effective against cotton strainers.

Laboratory tests will be continued during 1952 though the stress will be on *Lygus*. The E.C.G.C. entomologists are able to breed this insect in large numbers and it is necessary that laboratory tests should be made on it in order to obtain a fuller understanding of the results obtained when using insecticides in the field.

Phytoxicity of BHC

Since BHC had been reported as phytotoxic to cotton, field and laboratory trials were carried out during 1951 to determine the magnitude and cause of this phytotoxicity. The field trial showed that BHC emulsions or wettable powders at two to three times the normal dosage rates could cause a variety of phytotoxic symptoms. There was a great deal of plant to plant variation and the symptoms disappeared rapidly when spraying ceased. Judged by weight of green bolls even the most severe symptoms earlier in the season caused no reduction in yield.

The general course of the damage was as follows. One week after spraying all leaves less than one inch long at the time of application showed a yellow green cloudiness. After fourteen days this had changed to a fine grained yellow-green mosaic. In cases of most severe damage very young leaves failed to expand and the growing points to elongate. It was apparent that the appearance of these symptoms did not depend upon the age of the plant but on the age of tissue; old leaves showed no symptoms.

As a general conclusion it would seem safe to use BHC emulsions or wettable powders on cotton at the normal rates of application. Insecticide trials later in the year in which BHC wettable powder was included showed this to be true.

Laboratory trials showed that whereas spray fluids containing known amounts of gamma BHC made from a commercial wettable powder and emulsion caused severe reduction in root growth, the same amount of gamma BHC made as a colloidal suspension from an acetone solution of pure gamma BHC caused very little reduction.

The detailed results have been discussed with a representative of the manufacturers and the problem has now been handed over to them.

Field Trials

In all cases where cotton was sprayed with insecticides the application was carried out by the E.A.A.F.R.O. member and his assistants and all records of *Lygus* population and damage were made by the E.C.G.C. entomologists and their staff. Towards the end of the season records of bollworm damage were made by the E.A.A.F.R.O. portion of the team.

In only two of the trials was the main interest the effect of insecticides. In the first of these, equivalent amounts of DDT were applied as a run-off spray, a low volume spray at six to twelve gallons/acre, a spray using volumes of water intermediate between the first two, and a dust. In a second trial DDT, BHC, Toxaphene, Dieldrin, Pestox III, and Parathion were compared.

Picking has only just finished on the experimental plots and records taken during the trials still have to be correlated. The factors concerned have shown themselves to be so involved and numerous that a summary at the present moment might be misleading. However, some of the main points are as follows:—

(1) *Lygus* is an extremely mobile pest and much work will have to be done to determine a suitable design and plot size for experiments in which insecticides are used.

(2) The small plots used were, however, adequate for studying less mobile pests, such as bollworm.

(3) From the bollworm records the following points emerged:—

(a) Even during wet periods DDT dusts are more effective than sprays against bollworm. Between sprays the use of large or small volumes of water for the application made no difference.

(b) It was possible to correlate rainfall and action of insecticides. DDT, BHC and E605 were rapidly leached by rain, whilst Toxaphene and Dieldrin gave the same control in wet or dry periods. The last two compounds may supply the answer to our most pressing problem, the need for an insecticide which will be effective under conditions of tropical rainfall.

(c) Under dry conditions DDT gave an extremely good control of bollworm, better than Toxaphene, but when the rain exceed 3″ per week it caused an actual increase in bollworm damage.

(d) BHC and Parathion, which have a short residual effect even under the best conditions, caused an increased attack under dry conditions and were no different from the controls under wet conditions.

(4) Yield figures show that cotton, owing to its method of bearing its crop, may to a considerable extent compensate for damage done by insects.

The full implications of these results will not be apparent until it is possible to examine the detailed figures. However, preliminary consideration shows them to be of sufficient importance to justify devoting next year's work in laboratory and field to studying them.

The points to be studied during the next year are briefly as follows:—

(1) Plot size and *Lygus* movement.

(2) The interaction of weather, residual effect of insecticides and the whole insect population of the cotton field, particularly the balance between pest and predator.

(3) The manner in which the cotton bears its crop and the effect of insecticidal control upon this.

(4) Bio-assays of insecticide deposits on cotton to determine the length of time for which the various compounds are effective under field conditions.

(5) This year's field results and preliminary laboratory trials suggest that some insecticides may have a repellent effect upon *Lygus*. Experiments to examine this possibility will be continued.

Plant Physiology

STAFF

J. Glover ..... *Plant Physiologist*
Miss C. M. D. Harrison ..... *Temporary Assistant*

Most of the year was occupied by the transfer from Amani but some confirmatory nutrition experiments were made before the move. They were directed mainly towards a study of the phosphorus content of the plant when limited nitrogen supply restricts growth. The results showed that even when reduced nitrogen supply severely restricts growth the plant tends to accumulate phosphorus in proportion to the level of supply of that element.

Neither in these experiments nor in the results of many grass analyses made available by Dr. Birch, has it been possible to find satisfactory evidence that measurement of the percentage phosphorus content of tops is a guide to the total amount of available phosphorus, particularly if nitrogen is limiting growth.

Since the role of water in the economy of agriculture in East Africa is very important, work on the simple method of assessing the agricultural potentialities of semi-arid areas by means of estimates of reliability of rainfall was continued in conjunction with the Statistician. It is hoped to prepare maps for the whole of the three East African territories showing the reliability of annual and seasonal rainfall above and below certain selected levels. The rough drafts of maps of the reliability of the annual rainfall at the 20″ and 30″ levels have already been completed.

Arising from this, a method of estimating, twelve months ahead, the expected range within which the monthly total rainfall is likely to lie is also being tested. So far it can only be described as promising, for only some 70% forecasts are successful. It has also been used to predict the "wetness" or "dryness" of seasons with greater success, and may, with simple modifications, enable agricultural officers to suggest alternative crops in potentially abnormal seasons.

At the request of the Pyrethrum Board of Kenya, made through the Department of Agriculture, an investigation is being made, jointly with the Department, on "bud disease" in Pyrethrum. This widespread disease mainly attacks and kills unopened buds, though it is also known to attack partially opened flowers. It is reported to be caused by a fungus *Ramularia bellunensis*. As it is said not to be susceptible to control by a wide range of fungicides applied by normal methods, it was suspected by various workers that it might in part be due to failure in major or minor element nutrition or that poorly nourished plants are more susceptible to attack by the fungus.

Personal observations and information received during visits to the Pyrethrum Experiment Stations and farms suggest that the climate in which the plant is grown is one of the most important factors in the development and spread of the disease. There seems little doubt that its severity increases in a damp, cool climate. A preliminary investigation of climate-disease relationships suggests that continuous dampness of the environment of the plant is more important than the actual amount of rainfall. In other words heavy rainfall followed by suitable drying conditions is apparently less dangerous than a sequence of damp dull days in a period of low rainfall. A detailed study of the eco-climate of the plant and the macro-climate of the field in relation to the disease will, therefore, be made in the coming season.

Simultaneously a study of growth and development of the plant will be undertaken particularly with reference to bud development and the possibilities of infection at an early stage. It is thought that this, together with the study of climate may assist the interpretation of some hitherto unexplained aspects of the apparent severity of attack at different stages in the flowering cycle. For example, observation and measurement have shown a very high ratio of diseased buds to healthy flowers at the beginning of the flowering season, and this ratio decreases as the number of flowers produced increases. A tentative explanation of this arises from the observations that during the dry season the plant is mainly a thick vegetative clump and that with the coming of the rains buds are produced within the clump and are later pushed out on long stalks. Later, many new buds arise on these stalks and only a few buds continue to be set and develop in the shelter of the clump. It seems possible that the eco-climate of the clump is such as to favour the spread of the disease, and when once the stalks are, for the most part, clear of the clump new buds produced on them develop in the macro-climate of the field where they are better ventilated and so less likely to develop under conditions which permit the growth of the fungus. As more and more buds are produced under these conditions the ratio of diseased to healthy flowers should decrease fairly rapidly, which indeed has been shown to be the case in a long experiment conducted by the Officer-in-Charge of the Pyrethrum Experimental

Station at Molo, Kenya. This tentative theory is also in agreement with observations made in the Congo and in Kenya that "splits" in their first year, which have poorly developed clumps, are less affected by the disease than second and third year plants which have developed bigger clumps. It also covers the observation by Congo workers that drastic cutting back of clumps gives a very marked reduction in the incidence of diseased buds. This reduction may, of course, also be due to the time-displacement of bud production so that new buds are set in a drier part of the season.

Growth studies may also explain why sprayings with fungicides, as carried out at present, are apparently ineffective. The thick mass of vegetation at the base of the plant is not easy to cover, and growth at some periods is fairly rapid, so that the frequency and methods of application of spray may have to be modified. Further, there is some suggestive but, as yet, inadequate evidence, that the plant is infected some considerable time before spraying is normally started, so alteration in the time of spraying may also be required.

Work on the nutrition of the plant has been started. Spectrographic measurements have shown that the diseased buds consistently contain less potash than healthy buds. This may of course be due to the withdrawal of potash by the plant from the dying tissues. A range of plants whose nutritional status is known is being prepared for infection experiments which will be made with full mycological collaboration.

Clove Research Scheme, Zanzibar

Staff

F. J. Nutman[1] ..... Director
Miss F. M. L. Sheffield[1] ..... *Plant Pathologist*
Miss F. M. Roberts[2] ..... *Mycologist*
M. J. Way[2] ..... *Entomologist*
Miss M. D. Cooper[1] ..... *Scientific Assistant*
Miss J. L. Smith ..... *Scientific Assistant*
T. E. C. Robins[1] ..... *Agricultural Assistant*

In addition, the following, engaged by the Zanzibar Government, were temporarily seconded to the Clove Research Scheme:—

F. L. Vanderplank ..... *Entomologist*
Miss B. M. Tait ..... *Scientific Assistant*

[1]Seconded from E.A.A.F.R.O.
[2]Seconded from Rothamsted Experimental Station, England.

Clove Research

The past year has seen rapid advances in some lines of research, and a closing down of others. Following on the recent discoveries bearing on the aetiology of Sudden-death it has been decided that

the Clove Research Scheme is to continue until late 1953, instead of closing down at the end of this year.

So far as Sudden-death is concerned, this year has seen a change of emphasis. As regards the virus hypothesis, all attempts experimentally to transmit the disease to the clove itself or to a range of possible indicator plants have given consistently negative results. These attempts have been very comprehensive and have involved the use of twelve possible insect vectors, linkage with *Cassytha filiformis*, every known method of mechanical inoculation, and grafting. In all, more than 5,500 attempts have been made. Anatomical, cytological, physiological, and biochemical studies have produced no positive indications.

Thus, all attempts to produce positive evidence, in place of the strong circumstantial evidence that supported a virus hypothesis, have so far been unsuccessful, and there is now a considerable weight of negative evidence against it. The study of young trees which chance to have become naturally grafted to older ones, referred to on page 39 of last year's Report, has shewn a highly significant connection between grafting and the death of the young tree following that of the older. This is strong evidence in favour of a pathogen, but throws little light on what it might be.

The re-examination of the possibility that a primary fungal pathogen might be concerned, in spite of the evidence to the contrary claimed by Campbell, has yielded rapid and encouraging results. In every one of the thousands of Sudden-death casualties examined a fungus has been found, and always the same one. This is a new species of *Valsa*: an account awaits publication. In the early stages of the disease the fungus can be found only with difficulty in the more distal portions of the root system, where it appears to ramify mainly in and near the cambium. Later it can be found in the larger roots, and after the death of the tree ramifies throughout the trunk and branches, producing a characteristic yellow stain. Some three months later the fructifications appear. Conclusive proof of its pathogenicity has been obtained, but there are definite indications that only mature trees can be attacked, all attempts to infect young ones having failed.

Attempts are now being made to induce mass attack on uninjured clove roots: this work cannot be expected to produce definite results for possibly a long time, but there are already indications that penetration of absorbing roots by the fungus is taking place.

Dieback of cloves, a disease of great importance economically, has been shewn, during the past year, to be caused by a fungal wound parasite. This fungus is also a new species of *Cryptosporella*, and an account awaits publication. Complete experimental proof of its pathogenicity has been obtained, and every form of the disease has been reproduced experimentally. In addition to its role in causing dieback, all observed deaths of young clove trees in the Sudden-death manner have been shewn to be caused by the same fungus.

Control measures are theoretically simple, and have been applied, on a plantation scale, with success. This work is now complete, and awaits publication.

The entomological studies of the insect populations of clove plantations, and of the relations between ants and scale insects are now completed, and will shortly be ready for publication. No further work on this subject is contemplated.

Other minor activities, such as soil-moisture studies, have been brought to a conclusion and results are being worked up for publication.

Coconut Research

The coconut research, briefly mentioned in last year's Annual Report (p. 40), has developed with great rapidity. At a very early stage it became evident that this work had such great potentialities that it should be continued, although it had no connection with clove research. The work was, therefore, proceeded with until such time as other arrangements could be made. The Zanzibar Government has now made financial provision, and has appointed an entomologist and an assistant. These will work, for the time being, in the Clove Research Laboratories, and the research will continue to be administered by the Director of Clove Research. The results reported on here, however, have been obtained by Clove Research Staff.

It has been found that not only in Zanzibar and Pemba but also on the East African mainland, coconut yields are very largely controlled by the incidence of *Theraptus*, a coreid bug. Certainly two, and possibly three, species are concerned. Both nymphs and adults feed on the female flowers and immature nuts, and cause their abscission. When older fruits are attacked they do not always drop, but develop into misshapen nuts, producing a low yield of inferior copra, and are covered with sunken black lesions which exude gum. This particular result of *Theraptus* attack has been known for at least thirty years as the "Gumming Disease of Coconuts" and has been generally considered to be due to adverse soil conditions.

Surveys in Kenya, Tanganyika and Zanzibar have shewn that good crops of sound nuts are produced where the palms are colonised by the ant *Oecophylla longinoda* which is predatory on *Theraptus*. In many districts, however, *O. longinoda* is preyed on and often eliminated by other ants, notably *Anoplolepis longipes*, *A. custodiens* and *Pheidole* spp. In some areas where *O. longioda* has been eliminated yields are virtually nil, and it is clear that *Theraptus* causes losses of crop in East Africa as a whole probably amounting to several millions sterling and the problem is one which deserves close scientific study.

A very large amount of information has been obtained which cannot conveniently be summarised in this Report but which is being prepared for publication. It should, however, be mentioned that in one area in Zanzibar, experimental control measures have produced a ten-fold increase in yield: such spectacular increases are not likely to be achieved in commercial practice, but it is clear that even partial control of *Theraptus* is likely to give large financial returns.

Work is now in progress fully to investigate possible control meaures, and in particular the ideal method of biological control through *O. longinoda*. This can perhaps only be done by suppressing or discouraging other ant species.

Publications:

Nutman, F. J., (1950). "Studies of the Clove Tree, III: The Effect of Sudden-death on Water Relations." *Ann. App. Biol.*, **37**, 584.

Nutman, F. J., Sheffield, F. M. L., Swainson, O. S., and Winter, D. W., (1951). "The Sudden-death Disease of Cloves and its Economic and Agricultural Significance." *Emp. J. Exp. Agr.*, **19**, 145.

Way, M. J., (1951). "An Insect Pest of Coconuts and its Relation to Certain Ant Species." *Nature*, **168**, 302.

Forestry

Staff

A. L. Griffith ..... *Silviculturist*
W. B. May ..... *Scientific Assistant*

Most of the forest problems of East Africa are interterritorial. Examples are the softwood schemes of all three territories, the mangroves of Kenya, Tanganyika and Zanzibar, and the mvule (*Chlorophora excelsa*) and the regeneration of hardwoods of all three territories.

As a result of extensive tours through the territories by the Silviculturist, the Horticulturist, and the work of the Forest Mycologist, a number of urgent problems have emerged. These tours were undertaken to appraise the priorities, and the list of research projects given below is by no means comprehensive but merely shows those which appear most urgent, and which we feel we can attempt with our present limited funds and staff.

The most urgent problems appear to be:—

(1) Information: Collection and Distribution.
(2) Standardisation of Research Procedure.
(2) Softwoods.
(4) Enumerations.
(5) Regeneration of Hardwoods.
(6) Short-term Tree Cropping.
(7) Yield Tables for Important Species.

(1) Information: Collection and Distribution

It was quickly apparent that much technical information existed in the territories, but it was usually scattered and difficult to find. A Forest Bureau has been established in E.A.A.F.R.O. which is collecting and filing all information it can get. It is noteworthy that in the year

that it has been functioning 832 specific files and 318 general files have been opened, and already much use is being made of them. Information is already going out as well as coming in.

From the above it is obviously desirable to take immediate action to publish information on certain special subjects such as:—

(a) The Silviculture of East African trees, to be modelled on Troup's monumental work on Indian trees. (Recommended by the 1950 meeting of the Specialist Committee on Forestry Research.)

(b) Compilation of a list of exotics introduced into East Africa. This was also advocated by a resolution of the Inter-African Forest Conference at Abidjan, for all African territories.

(c) Compilation of a bulletin on seed weights, viability and storage of seeds of East African trees and introduced exotics.

(d) Compilation of an East African forest bibliography.

(e) A note on the correlation of current technical forest terms in use in East Africa. This was also recommended at the Inter-African Forest Conference.

One of the main reasons for the urgent necessity for these publications, is the fact that owing to the war and post-war development, most of the forest departments consist of young officers, and technical books are few and far between. They, therefore, have great difficulty in quickly learning their trees and their silviculture.

(2) Standardisation of Research Procedure

It was soon obvious that research procedure must be standardised as most of the territorial research officers were new to the work. As a result of the recommendations of the 1950 meeting of the Specialist Committee on Forest Research, the Indian Silvicultural Research Code has been adopted as a basis, and standard forms for the recording of research data have been brought into use in E.A.A.F.R.O. and in all the territories. This tends to minimise the recording of superfluous data, while at the same time preventing the overlooking of necessary information. It also makes the work of one territory immediately intelligible to another territory.

(3) Softwoods

Softwoods are one of the most urgent problems, and their importance may be judged by the very large proportion of forest expenditure which is being put into them. The projects under this head may be sub-divided as follows:—

(a) Seed Problems.

(b) Nursery Problems.

(c) Short-term Planting-out Problems.

(d) Trials of Further Exotics.

(a) *Seed Problems*

One of the main softwoods is the cypress group of which a number of species have been introduced. The seed problems of this group are mainly due to (1) hybridisation and (11) disease susceptibility.

(i) *Hybridisation.*—Most of the species are hybridising, and the seed collected from one tree produces a very mixed progeny of which some are useful, and some are almost useless, and these characters are not apparent often for a number of years.

At Muguga we have started a nursery, and even in the first year some rather startling results have been obtained. In collaboration with the Silviculturist, Kenya, we started single tree progeny tests. Seed was collected from a number of the best trees in the best plantation in Elburgon. It was sorted by size and each size from each tree was sown separately. On germination it was noticed that seed of the same size from a single tree produced different numbers of cotyledons. These were at once segregated and pricked out in separate boxes. At the end of the year, the different sizes of seed and the different numbers of cotyledons had produced no appreciable differences in vigour or size of the plants. But they may produce trees of different growth forms in the adult stages. These seedlings are being planted out separately these next rains for future study. The experiment is being repeated.

The eucalypts, wattles and pines are also apparently hybridising, and in consequence this work is likely to be greatly expanded in future.

Experiments made on vegetative reproduction generally failed, because propagating beds and bottom heat were then unavailable. They are being repeated under better conditions.

(ii) *Disease Susceptibility.*—The canker disease of cypress (*Monochaetia unicornis*) attacks the different species of cypress to different extents, and hence we want to select and breed, not only superior cypress strains, but also disease-immune strains. This is, of course, complicated by the hybridisation described above. Attempts are being made to eliminate disease-susceptible types and to establish seed plantations of good stock. This has not yet got past the nursery stage.

(b) *Nursery Problems*

Most softwood nursery work in the territories is somewhat crude compared with standards elsewhere. Mr. May toured the territories to advise in basic nursery work. Nursery results also vary enormously.

In consequence a forest nursery primarily for softwoods was started in Muguga during the year. In general, the territories can raise cypress and the Monterey pine (*P. radiata*) to a sufficient size for successful planting out in one year, but with most other pines and softwoods it is difficult to do so.

Experiments this year have shown that suitable preparation of the nursery bed by the addition of chopped turf, sand, and compost

to the usual soil, and a mulching with wattle factory waste, together with a more controlled watering, can produce healthier plants, some 15% bigger in the same time. This may eventually ease large-scale nursery work and save costs.

Experiments were also carried out with pine and cypress by fertilising the seed boxes with nitrogenous, phosphatic and potassic nutrients, and their combinations. This experiment has not been going long enough to give definite results, but it is already noticeable that the fertilised plants are, in general, some 50% bigger than other non-fertilised stock.

Another nursery problem being investigated is that of the mycorrhizal infection of new nurseries. Pines need such an infection and the usual method is to introduce soil from existing pine plantations. We are endeavouring to find a method of producing a concentrated "mycorrhizal brew."

All the above experiments are being repeated and extended. Experiments on the different methods and frequency of root pruning (such as knifing, piano wire, etc.) are being started.

(c) *Short-term Planting-out Problems*

We have now got to the stage of starting short-term planting-out experiments. Among the problems to be tested in the coming year are:—

(i) Best size and age of transplant. This is particularly necessary as opinion in the territories varies greatly.
(ii) Different types of soil preparation.
(iii) Different methods of weeding.
(iv) Box and pot transplants, bed transplants and seedlings.

(d) *Long-term Planting-out Problems*

Main problems under this head are:—

(i) Period and intensity of pruning.
(ii) Period and intensity of thinning.
(iii) Effect of planting espacement.

These at present are being dealt with by the territories.

(e) *Trial of Further Exotics*

Many introductions of many species have been made into East Africa, and in a number of cases the records of the introductions have been lost. We are, therefore, this year, establishing an arboretum, obtaining seed from the original habitat of the species as far as possible.

This will not duplicate the long-established Kenya Forest Department arboretum in Nairobi for, as well as raising specimen plants, we propose to raise small specimen plantations of each species, so that we shall have examples of trees grown under plantation conditions as well as under open conditions. In addition, many of the species already introduced may not have had a fair trial, and it is by no means certain that East Africa already has the species most suitable.

(4) Enumerations

Many forests in East Africa are being, and are to be, fairly heavily worked, and for the purpose a great deal of enumeration work is being done. This work is expensive in time and staff, but it is essential to know what is in the forest, if it is to be worked and developed. We want to find the most suitable, economical and efficient methods for stocktaking in our forests. Research work in this subject has been going on in the territories and in E.A.A.F.R.O. for the past eighteen months, and will be continued. A separate paper on the results obtained so far has been written by the Silviculturist, E.A.A.F.R.O., and submitted to the coming Commonwealth Forestry Conference in Canada where the subject is being discussed.

(5) Regeneration of Hardwoods

The hardwood forests are being exploited, and in general, regeneration is not satisfactory by either natural or artificial means. Experiments in this subject have been initiated and will be continued. Owing to the distribution of these hardwood forests the part E.A.A.F.R.O. has so far played has been advisory, and largely in the design of experiments for the territories. These remarks also apply to the indigenous softwoods — cedar and podo.

(6) Short-term Tree Cropping

Short-term tree cropping over rotations of six to twelve years of such crops as wattle and gums are said to exhaust the soil, and therefore, to lead to progressive deterioration in yield. An investigation has been started to determine whether the decrease in yield is due to to stool mortality and stool deterioration (as was found to be the case in Southern India for *E. globulus*) or whether it is due to genuine soil deterioration.

This project involves (a) the collection of information on yields (which is in progress) and (b) comparison of soils which have been under wattles and gums for many years, with natural forest soils (which is in progress) and (c) the laying out of a number of experimental plots and sample plots in suitable crops. The project will take five to ten years.

(7) Yield Tables for Important Species

Information on tree crop growth in East Africa is practically non-existent. The only existing information is for cypress, and most of this was collected for *C. macrocarpa* which has now been given up because of the canker disease. This project involves the laying out and periodical measuring of a large number of sample plots and tree-increment plots for a number of species. It will take some fifteen to twenty years before sufficient reliable information is available for any one species, and hence it should be started as soon as possible.

Publications:

Griffith, A. L., (1951). "Watershed Management Research in the U.S.A." *E.A. Agric. J.*, **16**, 190.

Griffith, A. L., (1951). "East African Enumerations — The Rondo Plateau (S. Tanganyika)." *Empire Forestry Review*, **30**, 179.

Griffith, A. L., (1951). "Notes on Some Conifer Nurseries in the South and West of the U.S.A." *E.A. Agri. J.*, **17**, 32.

Griffith, A. L., (1951). "Watershed Management Research in the U.S.A." *Proc. Nairobi Sci. and Phil. Soc.*, **5**, 59.

Griffith, A. L., and Trapnell, C. G., (1951). "The Value of Aerial Reconnaissance for Land Use in the Tropics." *Proc. Nairobi Sci. and Phil. Soc.* (in press).

Griffith, A. L., (1951). "The Broadening Outlook." *E.A. Agri. J.*, **17**, 51.

Systematic Botany

STAFF

P. J. Greenway ..... *Botanist-in-Charge*
B. Verdcourt ..... *Botanist*
Count Staryenski ..... *Scientific Assistant*

The year 1951 covered by this Report is the first full year of the East African Herbarium in its new quarters in Nairobi.

Over one hundred and twenty-five visitors from East Africa and other regions have visited the building, some of them, such as Mr. A. V. Bogdan, Pasture Research Officer, Kenya, Dr. F. Piers, Nairobi, (who is making a study of Kenya orchids) and members of the Kenya and Uganda Natural History Society have made full use of the botanical collections and the books available in the library.

In the early part of the year we continued to provide office accommodation for some of the staff of the Desert Locust Control; on their departure we gave office space for the remainder of the year to the Business Manager of the *East African Agricultural Journal*.

Housing accommodation, especially for the African staff, is still a major problem. At present three of the African staff have had to be housed at Muguga in very limited quarters, and transported daily to and from Nairobi — over thirty miles for the double journey.

The Herbarium

In the course of the year 264 accessions of botanical material totalling 6,945 specimens were received. Of these 4,011 were for naming and 1,572 were named and received in exchange. Of this material the more important collections were from: —

Kenya.—The Agricultural Department, 433 (Mr. G. W. Jeffery, 78; members of the Scott Agricultural Laboratories, 42; Pasture Research Officers, Messrs. A. V. Bogdan, 273 (mostly named) and R. Strange, 32). The Coryndon Museum, 115 (Messrs. P. R. O. Bally and E. Pinhey). The Desert Locust Survey, 19. The East

African Herbarium, 514 (Messrs. P. J. Greenway, 73; E. Kirrika, 166; Count A. Staryenski, 9; B. Verdcourt, 206; G. Williams, 215). The Forest Department, 16. The Government Chemist and Police Departments, 5. The Tea Research Institute of East Africa, 3. The Veterinary Department (Dr. P. Thorold, 35). Sundry private collectors, 344.

Tanganyika.—The Administration (Mr. R. Tanner, 29). The Agricultural Department, 66 (Messrs. G. B. Wallace, 14; J. D. Hunter-Smith, 20 and F. G. Smith, 28). E.A.A. & F.R.O., Amani, (Mr. R. F. W. Nichols, 4). The East African Herbarium, 218 (Messrs. P. J. Greenway, 152; and G. Williams, 66). The Forest Department, 878 (Messrs. W. M. Carmichael, 26; W. J. Eggeling, 453; J. S. Groome, 18; J. F. Hughes, 81; M. McCoy Hill, 19; M. S. Parry, 34; J. E. A. Proctor, 15; S. Semsei, 46; G. Watkins, 70; and L. G. T. Wigg, 46). The Government Chemist, 25. Overseas Food Corporation, 203 (Messrs. W. E. Bond, 30; A. H. Bunting, 2; B. Anderson, 108; J. C. Duerden, 8; C. Evans, 43; D. R. Grantham, 2; and J. D. Lea, 10). Termite Research, Amani, (Miss B. Kemp, 34). The Veterinary Department (Pasture Research, Mr. H. J. van Rensburg, 91). Miscellaneous, 3.

Uganda.—The Agricultural Department (J. W. Purseglove, 129). The E.A. Fishery Research Organisation, 2. The E.A. Tsetse and Trypanosomiasis Research and Reclamation Organisation (Mr. T. Jarrett, 395). The Forest Department (H. C. Dawkins, 175).

Somalia.—Messrs. W. E. Bond and J. Pechanec, United Nations Mission, 110.

In addition material was received for naming from the Belgian Congo, Northern Rhodesia, South Africa, the Botanic Gardens of Berlin, Brussels and Geneva, from the latter three herbaria in connection with Mr. Verdcourt's researches on *Cuscuta* and *Virecta*.

Over 1,570 named specimens were received from the following: The Agricultural Department, Kenya (Mr. A. V. Bogdan, 46 grasses). The Herbarium Universitatis Florentinae, . Instituto Botanico, Florence, Italy, 150 mostly from Eritrea. The Missouri Botanical Garden, St. Louis, U.S.A., 625 Tropical Africa, most Belgian Congo. The Royal Botanic Gardens, Kew, 405 (many collected in Portuguese East Africa and Tanganyika by Mrs. H. G. Faulkner) and from Prof. T. Reichstein, Basel University, Switzerland, 10 *Strophanthus* spp. These donations of named material add greatly to the value of the East African Herbarium, those from Florence and Missouri in particular because they contained classical specimens which are referred to in literature such as the *Flora of Tropical Africa*.

Duplicate specimens amounting to over 3,500 were distributed, mostly to the following: The British Museum (Natural History), London, 9. The Herbarium, Universitatis Florentinae, Instituto Botanico, Florence, Italy, 151. Missouri Botanical Garden, St. Louis, U.S.A., 600. The National Herbarium, Pretoria, South Africa, 211 The Royal Botanic Gardens, Kew, 946.

Loan material for study amounting to over 1,300 sheets was received from the following: The Botanical Department Natural History Museum, Vienna, 117 *Pentas* spp., etc., returned. The Botanical Museum and Herbarium, Utrecht, Holland, 10 *Pentas* spp., etc., returned. The Royal Botanical Gardens, Kew, 40 *Pentas* spp., 55 *Cuscuta*. The Museum National d'Histoire Naturelle (Phanerogamie), Paris, 2 *Pentas* spp., returned. The Botanischen Gartens and Museum, Berlin-Dahlem, 187 Rubiaceae. The Herbarium, Universitatis Florentinae, Instituto Botanico, Florence, Italy, 10 *Pentas* spp., returned. Museo di Storia Naturale Instituto delle Missioni Consolata, Turin, Italy, 23 Gramineae and Rubiaceae, returned. Mr. Peter Hill, Sotik, Kenya, 21 Mt. Kenya plant photographs for naming, returned. The Conservator of Forests, Ibadan, Nigeria, 15 *Pentas* spp., returned. The Instituto Botanico, Universidade de Coimbra, Portugal, 58 *Pentas*, *Pentanisia* and *Otomeria* spp., returned. The Department of Botany, University of the Witwatersrand, Johannesburg, South Africa, 1 photo *Vanilla* sp. for naming, returned. The Botanic Station, Botanical Gardens, Durban, South Africa, 41 *Pentas* spp. The National Herbarium, Pretoria, South Africa, 200 Rubiaceae, returned. The Bolus Herbarium, University of Cape Town, South Africa, 54 Rubiaceae, returned. Branch of Botany and Plant Pathology, Department of Research and Specialist Services, Causeway, Southern Rhodesia, 89 Rubiaceae, returned. The Botanical Department, State Museum of Natural History, Stockholm, Sweden, 48 *Pentas* spp., returned. The Botanical Museum, the University of Lund, Sweden, 63 Rubiaceae. Institute of Systematic Botany, the University, Uppsala, Sweden, 21 *Pentas* spp., returned. The Botanical Museum, University of Zurich, Switzerland, 2 *Pentas* spp. The Conservatoire and Jardin Botaniques, Geneva, Switzerland, 2 photos of *Virecta*. The Department of Agriculture, Tanganyika, 13 for naming, returned. The Forest Department, Tanganyika, 132 Flacourtiaceae, Oleaceae, etc., for naming, returned. Overseas Food Corporation, Tanganyika, 7 for naming, returned. E.A. Tsetse Research and Trypanosomiasis Research and Reclamation Organisation, Tanganyika, 20 *Pentas* spp., returned. U.S. National Museum, Smithsonian Institution, Washington, U.S.A., 25 *Pentas* spp., returned. The New York Botanical Garden, New York, U.S.A., 29 Rubiaceae returned.

Mr. B. Verdcourt's account of the genus *Cuscuta* for the Flora of Tropical East Africa has now been completed and sent to Kew. He is now engaged on a revision of *Pentas* and related genera of the Rubiaceae and grateful thanks are due to most of the institutions listed above for their very generous loans of material for study, particularly those on the Continent whose loans have been so rich in type specimens.

Count Staryenski has been engaged in indexing the native names and uses of East African plants and translations from the French, German and Italian, mostly German, into English of important taxonomic papers, particularly in connection with the families Rubiaceae, Meliaceae and Sapotaceae.

Over 1,200 sheets were loaned for study to the following: The Royal Botanic Gardens, Kew, 703 sheets, *Albizzia*, *Ascelepiadaceae*, *Galium*, *Oleaceae*, *Rhus* and *Utricularia*. Dr. Schulze, Botanisches

Gartens and Museum .Berlin-Dahlem, 263 sheets, *Impatiens* spp. Prof. Dr. K. Suessenguth, Botanischen Staatssammlung, Munchen, Germany, 110 sheets, *Centemposis* and *Cyathula* spp. Prof. C. E. B. Bremekamp, Botanisch Museum, Utrecht, Holland, 2 sheets. Prof. Dr. R. Pichi-Sermolli, Herbarium, Universitatis Florentinae, Instituto Botanico, Florence, Italy, 58 sheets, *Blaeria* spp. Dr. T. Norlindh, the Botanical Museum, the University, Lund, Sweden, 42 sheets, *Chrysanthemoides*. Miss R. H. Lowe, E.A. Fisheries Research Laboratory, Jinja, Uganda, 1 sheet, *Lagarosiphon*. Dr. J. B. Hutchinson, Cotton Research Station, Namulonge, Uganda, 1 sheet, *Gossypium*. Prof. E. B. Babcock, Division of Genetics, University of California, U.S.A., 8 sheets, *Crepis* spp. and Dr. E. E. Sherff, Chicago Natural History Museum, Chicago, U.S.A., 61 sheets, *Bidens* and *Coreopsis*. The request for all the E.A. Herbarium specimens of the family Oleaceae by Kew is for the preparation of another part of the Flora of Tropical East Africa.

Living plants and seeds to the number of 76 species have been sent to Cambridge Botanic Gardens; the Royal Botanic Gardens, Kew, (Asclepiadaceae, Cucurbitaceae, Euphorbiaceae, etc.); the Institute National Agronomique, Paris, (Cucurbitaceae); the Department of Agriculture, Kenya, (*Saccharum spontaneum*); Missouri Botanical Garden, St. Louis, U.S.A., and the New York Botanical Gardens, New York, U.S.A.

Seeds of *Funtumia* and *Motandra* have been supplied to the Colonial Products Research Council for chemical investigation. The plant material of *Phyllanthus engleri* Pax sent to the Council in June, 1950, has been investigated at Cambridge University and from it a new alcohol was isolated for which the name phyllanthol is suggested (see the *Journ. Chem. Soc.*, 1951, (506), pp. 2296-2297); this alcohol is being further investigated. The dried tubers of *Dioscorea dumetorum* (Kunth) Pax *D. sansibarensis* Pax and *D. quartiniana* A. Rich. were supplied, at their request, to Messrs. Merck & Co. Inc., Rahway, New Jersey, U.S.A., for their chemical investigations into certain sapogenins.

Some 5,400 specimens have been determined during the year and notes and information on a wide variety of subjects in connection with plants and their products supplied to technical departments of governments in East Africa, private individuals, commercial firms and institutions at home and abroad. These include over 200 specimens for the Agricultural and Forestry Departments of Kenya. Food plants of insects in the Bwamba Forest, Uganda, for Mr. E. Pinhey, Coryndon Museum. Over 80 specimens for the Agricultural, and over 600 specimens for the Forest Departments of Tanganyika; some 150 specimens for the Overseas Food Corporation, Tanganyika, for surveys of vegetation and host plants of insects attacking groundnuts and about 90 fodder and pasture plants for the Pasture Research Officer, Veterinary Department, Tanganyika. For the Agricultural and Forest Departments of Uganda over 400 were named for vegetation and timber surveys. The largest collection dealt with was the naming of over 2,400 Portuguese East African plants collected by Mr. Gomes Pedro, Junta de Exportação Do Algodao Colonial, Lourenço Marques, in connection with land and vegetation surveys. The most difficult

was the naming of over 110 Somaliland plants collected by Messrs. W. E. Bond and J. Pechanec of the Food and Agricultural Organisation on the United Nations Missions to Somalia.

The task of amalgamating the Coryndon Museum Herbarium with that of the Amani Herbarium has been very much delayed owing to absence on leave, but a further 58 families have been transferred.

Whilst naming collections and amalgamating the two herbaria twenty further type specimens were found; the following new species were described from the herbarium:—

Acacia gloveri Gilliland (Mimosaceae) in *Kew Bull.*, 1951, **1,** p. 139. *Glover & Gilliland* 388! type.

A. impervia Gilliland in *Kew Bull.*, 1951, **1,** p. 139. *Glover & Gilliland* 386! type.

A. walwalensis Gilliland in *Kew Bull.*, 1951, **1,** p. 140. *Glover & Gilliland* 392! type.

Anemone thomsonii Oliv. var. *angustisecta* Milne-Redhead & Turill (Ranunculaceae) in *Kew Bull.*, 1950, **3,** 389. *Greenway* 7639! type.

Bidens kigeziensis Sherff (Compositae) in *Amer. J. Bot.* 38, **1,** p.67 (1951). *Purseglove* 2189! type.

B. navicularia Sherff in *Amer. J. Bot.*, 38, **1,** p. 68 (1951). *Thomas* 4051! type.

B. setigeroides Sherff var. *munita* Sherff in *Amer. J. Bot.*, 38, **1,** p. 68 (1951). *Thomas* 4385! type.

Brazzeia longipedicellata Verdcourt (Scytopetalaceae) in *Kew Bull*, 1950, **3,** pp. 344-7. *Purseglove* 2002! type. *Greenway & Eggeling* 7105! para-type.

Bulbophyllum encephalodes Summerhayes (Orchidaceae) in *Harvard Mus. Leaflets* 14, **9,** p. 228 (1951). *Moreau* 6! type.

Ceropegia brosima Bruce & Bally (Ascepiadaceae) in *Kew Bull.*, 1950, **3,** p. 368. *Boy Opiko* 697 (*Bally* S831)! type.

C evelynae Bruce & Bally in *Kew Bull.*, 1950, **3,** p. 370. *Forbes* 65! type.

C. helicoides Bruce & Bally *in Kew Bull.*, 1950, **3,** p. 371. *Mrs. Joy Adamson* (*Bally* S153)! type.

Eriocaulon annuum Milne-Redhead (Eriocaulaceae) in *Hooker's Ic. Pl.* t. 3389 (1939). *Greenway* 5389! type.

E. strictum Milne-Redhead in *Hooker's Ic. Pl.* t. 3388 (1939). *Fitzgerald* 5213/3! type.

Liparis odontochilos Summerhayes (Orchidaceae) in *Harvard Mus. Leaflets*, 14, **9,** p. 226. *Dale* 1860! type.

These additional records bring the total number of known isotypes in the herbarium up to 556.

During the year a total of 8,172 specimens were laid away; of these 3,360 were transferred from the Coryndon Museum Herbarium; 465 were grasses; the grass collection now contains 8,216 sheets; the grand total amounting to 70,720 sheets for study.

During leave in the U.K. much time was spent at Kew revising a paper on the Vegetation of Mt. Hanang, Tanganyika, consulting literature and the botanical material of the genus *Pentas* and naming critical specimens. Visits in connection with this work were made to the British Museum (Natural History), London, the Imperial Forestry Institute, Oxford, and to the Cambridge Botanic Gardens and thanks are due to the directors of these institutions for the facilities afforded.

Mr. B. Verdcourt also worked at Kew during his leave on his revision of the genus *Pentas*.

Field Work

It was not possible for the staff to spend much time in the field during 1951. Mr. Verdcourt, however, has, outside the herbarium hours, collected assiduously in the Karura Forest some three miles out of Nairobi — a small forest stand composed mainly of *Piptadenia buchanani* Bak.; an Annonaceous tree new to science has been discovered during this collecting. From mid-July till near the end of September, Mr. Greenway used the remainder of his leave to visit the Eldoret and Kakamega Districts of Kenya; the Moshi, Lushoto, Morogoro and Tanga Districts of Tanganyika, making collections on the lower slopes of Mt. Meru, Arusha Chini, the lower slopes of the Nguru Mountains and the Uluguru Mountains; a visit was also made to the Lukwangule Plateau and to Mtibwa at the foot of the Ngurus. Some 214 specimens in quadruplicate were collected; they contain quite a few species that are new or little known to science, and will be named in due course.

Owing to housing difficulties the senior African Herbarium Assistant, George Williams, was transferred to Eldoret where he was stationed for seven months with Mr. L. R. Doughty, Officer-in-Charge, Fertiliser Scheme. He collected mainly in a grassland area with scattered forest patches and riverine fringing forest and obtained 215 specimens in quadruplicate most of which were herbs. This collection has still to be worked out and distributed.

In June another African Assistant, Edward Kirrika, accompanied Mr. J. G. Williams of the Coryndon Museum, to the Kenya-Ethiopian Boundary Commission for six weeks collecting in the Northern Frontier Province, Kenya. He collected over 140 specimens in quadruplicate in the Isiolo, Wajir and Moyale Districts; a duplicate set of this collection was sent to Kew and it is reported that it contains several novelties. He also accompanied Mr. Williams at the beginning of December for a few days to the Upper Tana River at Kiambere, Machakos District.

Thanks for assistance in various ways are due to Mr. L. R. Doughty; the Conservator of Forests, Tanganyika, (Dr. W. J. Eggeling) and to members of his staff; and to members of the Coryndon Museum for help given in the field.

B. Verdcourt

Owing to the prior claims of the work on several *Rubiaceous* genera little time has been available for zoological work. Some 400 specimens have, however, been collected locally and presented to the Coryndon Museum and museums abroad. Special collections of *Meligethes* beetles have been continued and about six new species sent home in quantity. These feed on the Labiate genera *Leucas* and *Leonotis* and the Rubiaceous genus *Pentas*. A number of *Neuroptera* have been collected and sent to Mr. D. E. Kimmins, the British Museum specialist. Several of these are new and two have already been described.

A new species of *Proisotoma* (Collembola) and what may be a new species of *Apus*, a fresh water crustacean, were collected by Mr. P. R. Hesse and communicated to the experts. Several queries from local people have been answered and material named for the Division of Insect Borne Diseases, Medical Department, Mombasa, and Mr. F. L. Hendrickx, I.N.E.A.C., Mulungu, Belgian Congo.

Nairobi is poor in Mollusca and several groups are rare or absent. The following land species and genera occur in the neighbourhood: *Trichotoxon* (rare), *Veronicella* (rare), *Kaliella*, *Leudoulxia*, *Trochozonites*, *Gulella* (rare), *Limicolaria* (rare), *Rachis*, *Subulinae*, *Trachcystis* (*Psychion*) *ambigua* Conn., and *Pseudoglessula mirabilis* Preston. The freshwater fauna is composed of *Biophalaria alexandrina pfeifferi* (Kr.), *Bulinus contortus* Mich., *Lymnaea* sp., *Viviparus unicolor* Ol., and *Caelatura* sp.

Large *Achatinae* do not seem to occur. On the nearby mountains *Vitrina* and *Helicidae* occur in the bamboo forests. It may be said, however, that molluscs form quite an insignificant part of the fauna in this dry upland area. Collecting has been mostly limited to the Karura Forest and Thika Gorge.

Publications:

Verdcourt, B., (1951). "A Note on the Genus *Tomichia*." *Rev. Zool. Afric.*, **44**, 173.

Verdcourt, B., (1951). "A New Species of *Trichotoxon* from Kenya." *Rev. Zool. Afric.*, **45**, 57.

Fertiliser Experiments

Staff

L. R. Doughty ..... *Officer-in-Charge*
D. W. Gourlay ..... *Field Experimentalist*
T. Graham ..... *Agricultural Assistant*
P. H. Hosegood ..... *Agricultural Assistant*
T. E. C. Robins ..... *Agricultural Assistant*

The Fertiliser Research Scheme, financed by a separate Colonial Development and Welfare grant, came to an end in 1950, but as the Departments of Agriculture could not immediately undertake to

continue the work it was decided that E.A.A.F.R.O. would carry on for one more season before handing over. The reduced field staff called for some reorganisation of activities and the final disposition during the past season was a field assistant at Ngomeni for the coast area, one at Ukiriguru Experimental Station for the Lake Province, and one at Bukura, Kakamega, for the central part of N. Nyanza. The remaining part of N. Nyanza and the Mbale District of Uganda was covered from Eldoret by the Field Experimentalist.

The season was generally a favourable one from the climatic point of view but animal and insect pests played havoc with many experiments. On the coast rats did so much damage to the germinating maize seeds that most experiments had to be replanted several times. In all other regions shoot and stem borers did very considerable damage to the sorghum crop.

Seventy-one major experiments and the same number of simple exploratory experiments were planted. Fifty-seven of the former and fifty-five of the latter were harvested. Thirty-four of the major experiments were on new sites, the balance being repetitions of experiments on old sites. Two of the experiments in the Mbale District were planted to provide a comparison of the effects of different types of nitrogenous fertilisers but the materials were not received in time to enable us to complete these.

On all experiments on new sites single superphosphate was used in place of Uganda rock phosphate, the basic rate of dressing being 2.08 cwt./acre. Other fertilisers used were as heretofore, triple superphosphate at 0.96 cwt./acre; soda phosphate at 2.08 cwt./acre; Uganda rock phosphate at 3.64 cwt./acre; sulphate of ammonia at 0.95 cwt./acre; muriate of potash at 0.48 cwt./acre; farmyard manure or compost at 5 tons/acre.

No change was made in the methods of application; all fertilisers except sulphate of ammonia and farmyard manure were placed in furrows about 3″ deep, covered with soil and the seed sown at a depth of about 2″. Sulphate of ammonia was applied by side-placement when the crop was established, about a month after planting, except for the early dressing in the time of application experiments, when it was applied in the drill before planting. The organic manure was applied broadcast and dug in for experiments on the flat and incorporated in the ridge on others. In a number of experiments in Nyanza and at the coast the rates of application of the phosphates were reduced to a half and a single basic dressing instead of the single and double basic rate.

Results

Nyanza Province, Kenya

The main objective of this year's experiments was to confirm and amplify the conclusions drawn from earlier experiments concerning the response of crops on the different soil types to phosphatic and nitrogenous fertilisers.

In N. Kitosh, where the most extensive soil type is a red earth on basement complex rocks, two major experiments on new sites with phosphate at half and single basic rates, whilst falling into line generally with past experience, were disappointing. In one case the experiment happened to overlap an area that had been heavily dressed with compost, although the experiment was sited by the owner as being outside the manured area. The other experiment suffered from severe competition with couch grass. Exploratory experiments scattered over this area showed in general a marked response to phosphates and nitrogen.

In the central portion of N. Nyanza, north and south of a line drawn from Kaimosi Mission in the east to Buholo in the west, the soil is a red earth of varying texture and extensively underlain by concretionary ironstone murram. In this region a general and big response to phosphates is confirmed. The response of all grain crops, finger millet, maize and sorphum is big. A single experiment with Sweet potatoes, however, show no appreciable response to phosphate. There is no apparent difference in the effect of triple or single superphosphate or sodaphosphate at the dosages used. On this soil type rock phosphate has been shown to have some effect on yield but on two experiments repeated this year the effect of rock phosphate is appreciably lower than that of soda- and triple superphosphate.

In round figures the overall proportionate increases in yield for grain crops on this soil type are: to a half dressing of sodaphosphate 38%, to a single basic dressing 43% and to a double basic dressing 57%. The corresponding figures for triple superphosphate are 38%, 48% and 60%. For single superphosphate, 44% for a half basic dressing, and 54% for a single basic; no double basic dressing was used for this fertiliser. The effect of sulphate of ammonia in this same region and over the same period is −7% for a half basic dressing, +6% for a single basic and +18% for the double rate. Seven experiments in which farmyard manure was used gave an overall increase in crop of 21%.

Around Busia and in the Nzoia basin repeat experiments confirmed earlier results. The phosphate response was maintained in the latter region and the nitrogen reponse in the former. In the north-west, however, on the red earths on granite, variable results were obtained this season. The most marked response was to nitrogen as before, but there were some significant responses to phosphates particularly on eroded sites.

Mbale District, Uganda

Three experiments in Busoga, repeated for a second season under sorghum, again showed a marked response to sulphate of ammonia. A new experiment at Bulumbi, near Busia, gave a significant response to phosphates, as did the old experiment nearby, and no response to nitrogen. Farther south, at Lumino, a new major experiment and three exploratories showed a marked response to nitrogen and small responses to phosphate. All these soils have been grouped as red earths on sandstones but the classification is doubtful.

The remainder of the experiments in Uganda, with one exception, were on red earths on granite and were mostly small exploratory ones and from them the earlier picture of outstanding responses to nitrogen was confirmed.

Of the three experiments made to study the effects of applying nitrogen at different stages in the development of the crop two were on red earth on granite and one on the volcanic soils of the foot slopes of Mt. Elgon. This last was not very satisfactory owing to damage to the sorghum by shoot and stem borers. The other two experiments were planted with finger millet and in both, significant increases in yield were obtained up to the double basic dressing of sulphate of ammonia; the response to an additional basic dressing did not reach the limits required for significance. On one experiment the time of application of the fertiliser made no difference but on the other the mid-season dressing, and this combined with the late-season application, gave the best results.

Lake Province, Tanganyika

Only one experiment was laid down on the hill sands, (itongo) this season and in this bulrush millet responded similarly to each of the three phosphates, single and triple superphosphate and soda-phosphate; there was also a significant response to sulphate of ammonia and farmyard manure.

Most of the experiments in this province were on the red, laterised fossil soils, (Kikungu), around Shinyanga. Sorghum throughout suffered very severely from borer damage and smut. Bird damage was heavy on some experiments with bulrush millet. The only really satisfactory crop was cotton and one experiment with this crop suffered to a small extent from theft of seed cotton. In spite of the general variability of the yields the results indicate a response to phosphate on this soil type, a marked response to farmyard manure and little response to sulphate of ammonia.

From the results of this season's experiments it is estimated that the sorghum crop was reduced by some 60% due to borer attack and of the heads matured about 50% were badly attacked by smut in spite of seed dressing. Under these circumstances the experimental results cannot be expected to be very convincing.

During the past season an experiment was laid down on the Muruku Station, Bukoba, and a series of exploratory experiments in the Tarime area of N. Mara. At Muruku it was completely ruined by partridges. Around Tarime, maize responded to sulphate of ammonia and gave variable responses to triple superphosphate.

Coast, Tanganyika

As stated earlier in this Report rat damage was serious during establishment. The end result was a very variable stand and considerable variability in the development of the crop. On the grey coastal sands on limestone there was, once more, a marked response to phosphatic fertilisers with only a small response to nitrogen and farmyard manure. An experiment under its third crop on the same

site showed a new and statistically significant response to potash. The red soils of the Usambara foothills appear to need phosphates but no conclusive evidence has yet been obtained. In the Handeni District three exploratory experiments show a response to phosphate and further work in this area would be well worth while. On the Wami plain, near Morogoro, two exploratory experiments showed no response to fertilisers.

General

Soil samples have been collected from all new experimental sites and some of the older sites that have been retained in the programme have been resampled. Owing to the move from Amani to Muguga, however, the analytical data were not available in time to correlate with the field results. A visit by the E.A.A.F.R.O. Soil Survey Section to some of our experimental sites has been of great assistance in our soil grouping problems.

Summary

In the wetter districts, on sedentary soils derived from granite, there is a widespread response to nitrogenous fertilisers. Where these soils have been exposed to erosion a response to phosphate may also be obtained. The area covered by these observations extends from the north-western part of N. Nyanza into the Eastern Province of Uganda. A response to phosphate and nitrogen is recorded on the red earths derived from basement complex rocks, gneiss, in the north-eastern corner of N. Nyanza. In the central portion of this sub-province there is a big response to phosphates on the soils derived from or overlying sediments and acid volcanics. In this area responses to nitrogen are not very marked.

In the drier areas soils of granitic origin appear to behave in the same manner to those of similar origin in the wetter areas. Laterised red earths in the semi-arid areas appear to respond to phosphates.

The sandy coastal soils are in general poor in plant nutrients and respond to phosphates and nitrogenous fertilisers and in some cases to potash. The heavier soils on basement complex rocks may be low in phosphates. Alluvial soils appear to have a balanced fertility.

A good deal more work is required in all these areas to determine economic rates and methods of application suited to native practice. There is no doubt that in most areas the judicious use of artificials would increase output of food crops to a very useful extent and encourage a more rational use of the land.

Acknowledgements

Once again it is a pleasure to be able to record the persistence of cordial relations with all co-operators, African and European, official and non-official, in the prosecution of our work, and on our withdrawal from active operations in the field to record appreciation of the loyal service of the African recorders seconded or attached to our team, now disbanded, during the past four years.

Soil Chemistry

Staff

H. F. Birch ..... *Chemist*
G. T. Chamberlain ..... *Spectrographer*
P. R. Hesse ..... *Chemist*
Miss A. L. Alexander ..... *Scientific Assistant*
Miss D. M. Cooper ..... *Scientific Assistant*
Miss E. Smith ..... *Scientific Assistant*

General

The transfer of the Soils Department from Amani and its reorganisation at Muguga took approximately five months (January to May), and laboratory work was resumed early in June, 1951. Miss Alexander remained at Amani to complete certain soil analyses (facilities for which were not, at the time, available at Muguga) and to supervise the packing of the rest of the equipment and the soil samples. Miss Cooper was seconded to the Clove Research Scheme, Zanzibar, in February. Miss Smith and Miss Alexander proceeded on home leave in August and December respectively, following their resignations.

The work done during 1951 is sub-divided for reporting as follows:—

(1) Soil and miscellaneous analyses.
(2) Soil phosphate investigations.
(3) The effect of termites on East African soils.
(4) Spectrographic investigations.

The soil and miscellaneous analyses were carried out by both the Spectrographic and General Analytical Sections of the Department. Because of the speed and reliability of spectrographic methods, the spectrograph is finding increasing application in analytical work. Originally used almost entirely for the determination of exchangeable bases in soils, it is now also employed, with marked advantages over purely chemical methods, for the determination of bases in plant material and other samples. An account of spectrographic work is given by Mr. Chamberlain later in the Report.

The soil phosphate investigations are a continuation of those described in the Annual Report for 1950, and satisfactory progress has been made. The main features of the work, and the conclusions that can be drawn from it, are described below.

Mr. Hesse, who was originally responsible for supervising the analytical work of the Department (excluding spectrographic analyses) and for carrying out minor investigations (see Annual Report for 1950) is now fully engaged on determining the effect of termites on East African soils. This work was started late in 1950 and is likely to occupy two to three years. An account is given by Mr. Hesse of the practicability of this work, the lines along which it is being carried out and of the progress so far made.

Soil and Miscellaneous Analyses

The number of soil samples received for analyses in 1951 was somewhat smaller than in previous years as a result of the closing down of the Kenya Highlands Fertiliser Scheme early in 1951. From the East African Fertiliser Scheme, under the direction of Mr. L. R. Doughty, 334 samples were received. These were analysed for exchangeable bases, carbon, nitrogen, pH, phosphates and mechanical fractions, making a total of about 5,000 separate analyses. A further 30 soils have been analysed for nitrogen on behalf of the Overseas Food Corporation. In addition, some 350 soils have also been collected and analysed (by chemical and spectrographic methods) by Mr. Hesse in connection with his investigations.

In the phosphate investigations, 63 grass samples have been analysed for phosphate, and spectrographically for bases. For advisory purposes twelve sisal samples, eight pyrethrum samples and eleven samples of water have also been analysed for bases. This work is discussed in more detail by Mr. Chamberlain.

Phosphate Investigations

H. F. Birch

In the Annual Report for 1950 brief reference was made to an inverse relationship which was established, for certain East African soils, between the degree of base saturation of the soil and the magnitude of response to added phosphate. The relationship was very significant and was based on three groups of experiments (56 observations) with wheat, millet and grass on various soil types ranging from pH 4.7 to 6.3. This work and the theory underlying the relationship has subsequently been described in more detail (see Publications). Since the degree of base saturation was so closely related to phosphate availability and response, whereas the amounts of acid-soluble, adsorbed and water-soluble phosphate in the soil showed no such conclusive correlations, it was suggested that in acid soils base saturation or related data, e.g. pH, were best suited to assessing the phosphate status of the soil and its likely behaviour to applied phosphates.

As a logical extension of this work attention was directed in 1951 to the analysis of plant samples from the fertiliser trials. Grass samples from the Highland Fertiliser Scheme trials were available for this study and 63 of these were analysed for phosphate and bases. The results obtained were of considerable interest. In the first instance both the percentages, and the amount of phosphate in the crop, were found to be very significantly and directly related to the degree of base saturation of the soil and slightly less so to the pH. The amount of acid-soluble phosphate in the soil, allowing for losses by adsorption during the extraction was also significantly and directly related to the percentage phosphate in the grass, but no such significant relationship was found with the amounts of acid-soluble phosphate (by direct extraction), adsorbed or water-soluble phosphate. A multiple regression of the percentage phosphate in the grass on both

the degree of base saturation and the amount of acid-soluble phosphate (allowing for adsorption losses during extraction) showed the degree of base saturation to be five times as effective a contributory factor to the percentage phosphate in the grass as the amount of acid-soluble phosphate.

These observations confirm the previous ones that a high degree of base saturation is, in acid soils, synonymous with the presence of available phosphate and, consequently, negligible responses to applied phosphate. With decreasing base saturation the availability of the phosphate in the soil decreases (as shown by the plant analyses) and the magnitude of crop response to added phosphate increases (as shown in the field experiments).

With regard to phosphate response as a function of the percentage phosphorus in the grass, it was established that when oven-dry grass contains 0.33% phosphorus, or over, no response to phosphate is likely, while if the percentage phosphorus is 0.23 or less, responses of 10% or greater may be expected in the absence of other limiting factors.

A study of the amounts and percentages of the more common cations (calcium, potassium, sodium, magnesium and manganese) in the grass samples revealed no obvious relationship between these values (singly and in combination) and either the phosphate status of the grass or the exchangeable base status of the corresponding soils; nor did the degree of base saturation of the soil appear, in these experiments, to be a factor limiting the base status of the plants.

The investigations, so far, have established that there is a direct relationship in acid soils between phosphate availability and the degree of base saturation. Moreover, it is highly probable that the available form of phosphate in such soils is that associated, in an unstable form, with the exchangeable bases. With increasing base saturation there is an increasing probability of soil phosphate being retained in this available form rather than in the more unavailable form associated with the clay colloid proper. The next stage in the work will, therefore, be to develop a method for determining the amount of such base-linked phosphate in acid soils. Conventional methods for the extraction of soil phosphate are not designed to isolate this available form from other less available forms nor does it appear that such fractionation can easily be accomplished by extraction methods alone. Assuming, however, that the amount of acid-soluble phosphate (allowing for adsorption losses during extraction) in the soil is distributed between the base-linked and less available forms, depending on the degree of base saturation and, further, that plant phosphate is derived from the base-linked phosphate, it should be possible, from experiments of the Neubauer type, to determine the distribution of acid-soluble phosphate between base-linked or other forms as a function of the degree of base saturation. Having worked out this distribution, a fair assessment of the amount of base-linked phosphate in a soil should be obtained from the amount of acid-soluble phosphate and the degree of base saturation. A preliminary study of data from the field experiments showed that when the degree of base saturation of the soil was 40% or less, none of the acid-soluble phosphate was

in the base-linked form while at 80% base saturation about 22% was in this form. These values are, however, merely indicative of the type of distribution to be expected. More precise values are awaited from the controlled experiments mentioned above, which have now been started.

Effect of Termites on Soils

P. R. Hesse

The large termite mounds in East Africa frequently exert a considerable influence on the growth of certain crops. The general effect on crops such as maize, sisal and tobacco is to improve both the growth and quality of the plants; tea, on the other hand, is adversely affected.

In 1936 the late G. Milne of Amani found a large accumulation of lime in an old termite mound near Tabora. This was remarkable because the surrounding soil was acidic. Following the publication of his discovery, other calcareous mounds were described by various workers who, unfortunately, never identified the species of termite which had built them and seldom reported on the nature of the surrounding soil. With regard to the fertility of termite mound soils, reports show that there is a wide variation in the amounts of nitrogen, phosphorus, potash and other nutrients. Altogether, however, the literature on the subject is scanty and represents a series of isolated observations rather than the results of one or more comprehensive investigations.

In view of the lack of data on this subject, and because of the large number of termite mounds in East Africa and the considerable influence, beneficial or otherwise, that they can exert on the crops grown on or near them, it was considered that a thorough investigation of the effect of termites on East African soils was justified. The method of approach to this problem is to carry out a detailed physical and chemical examination of mounds built by different species of termites under various conditions of climate and soil type. The soils immediately surrounding the mounds are also being analysed. In this way the relationship between environment and the mound can be established and an explanation afforded of the effect of the mounds on vegetation and crops. Further, it will then be possible to advise on the desirability or otherwise of spreading the mounds on the adjacent land.

So far thirteen mounds from various parts of Tanganyika have been examined. This has involved the collection and preparation of 350 soil samples on which about 12,500 determinations have already been completed. These determinations include the usual soil analyses and water-soluble salts, nitrates and chlorides. Physical measurements, such as water-holding-capacity, size of sand grains, etc., will also be made. The results so far obtained have indicated the lines along which the work should be continued and the kind of relationship to be expected. Definite conclusions will be possible when further mounds have been sampled and analysed.

Spectrochemistry

G. T. Chamberlain

Technique

Several alterations have been made, the most important being the addition of a stepped sector to eliminate the dilution and re-exposure of the soil extracts for calcium determination and thereby halving the time required to expose a plate. A ten-degree aperture was cut in the sector to give a theoretical reduction in intensity of 1:36, but in practice, due to the photographic intermittancy effect, the reduction was found to be of the order of 1:50 and varied with intensity as indicated by a lower value for the photographic contrast factor for a stepped calibration as compared to an uninterrupted calibration on the same plate. The calcium concentrations of the standard solutions were increased accordingly, so that line densities of standards and samples alike were read from the stepped portion of the spectrum. For the occasional sample of lower calcium content, it was possible to read the density from the uninterrupted spectrum and obtain the true content by multiplication by a factor derived from the mean of twelve plates on which high and low calcium standard solutions were exposed. By use of the sector it has become possible to determine calcium contents of the soils from 0.03 to 30 m.e. per 100 gm. soil with the one solution.

Further modifications have consisted of (1) increasing the magnesium content of the standard solutions such that a concentration of 16 milli-equivalents can be determined without dilution; (2) plotting the final graphs on double logarithmic paper to obtain a replica of the photographic characteristic curve thus facilitating extrapolation to higher contents. When extrapolation to zero was necessary for low contents, the linear plot was retained.

Soil Analysis

Except for the alterations given above, the method of soil analysis has been the same as that devised by Dr. Black and since analysis was restarted in June some 334 samples from the Fertiliser Schemes have been analysed, as reported earlier. In addition, the spectrograph has been used for the analysis of over 200 soils for Termite Research, nine from the Muguga farm and six from the sisal investigations, discussed below. These 549 soils have, with duplicates, involved over 3,000 estimations of exchangeable bases. Also over .600 determinations were made for exchangeable hydrogen.

Plant Analysis

During the year the spectrochemical method has been applied to plants for the determination of Ca., Mg., Mn., K. and Na., and two techniques have been considered. Firstly, there was the usual ashing and extraction with hydrochloric acid and, secondly, a method of direct extraction of the plant material as suggested by G. Smith of the Rothamsted Experimental Station. The two methods were found to compare favourably for samples which were finely divided and the direct extraction was used for the grass analysis described earlier and for the analysis of healthy and diseased pyrethrum buds for the plant physiologist. More of these samples are expected.

Investigations have been started on the analysis of sisal for the High Level Sisal Research Station, Thika, to establish the relationship, if any, between the diseases of sisal and its base status. As no milling machine was available at this time, the ashing technique was adopted and, so far, the investigation has been confined to the study of leaf tip dieback, a disease peculiar to Kenya. These analyses have confirmed the earlier chemical work by Dr. Black, which showed a marked concentration gradient of Ca. and Mg. in the leaf, increasing from base to tip. The K. content appeared to be fairly constant in the lower half of the leaf with a tendency to decrease toward the tip. It is too early yet to draw any conclusions as the analyses are not complete and further samples will be required.

Other Analyses

In addition to the soil and plant analysis, eleven samples of lake and river water were received from the East African Fisheries Research Laboratories, Jinja. The Lake Victoria water showed roughly constant composition in the Buvuma Channel down to a depth of 19 metres and at Bugagia down to 60 metres. The inflow to the lake from the River Nzoia was of the same composition as the lake itself, but water from the River Nyando showed a calcium content about 2.5 times the lake water (16 p.p.m. compared to 6). A sample from the Semliki River flowing from Lake Albert was rich in salts with K. and Na. each being present between 80 to 90 p.p.m. and Mg. 33 p.p.m. Calcium was relatively low at 10 p.p.m. and strontium high at 0.47 p.p.m., whereas all other samples showed a strontium content around 0.1 p.p.m.

An improvised AC arc was used for the examination of two samples from the Soil Survey Section. They were found to be similar in character to ilmenite.

Future Programme

Up to the present there has been little work done on the base status of plant materials in East Africa. Now that a start has been made, this will be developed to the full. Seasonal changes in the composition of the plants must be studied, as this is likely to be particularly important in tropical climates where clearly defined dry seasons occur.

In the case of sisal, other diseases will be examined in turn, but in time this work will be taken over by the Tanganyika Sisal Growers' Association, when a spectrochemical laboratory is being set up at their Ngomeni Research Station. This is discussed more fully under the heading of "Advisory Work."

During 1951, orders were placed for the Littrow spectrograph and the ancillary equipment necessary to carry out the trace element determinations using the cathode layer carbon arc. The methods to be used are those devised at the Macaulay Institute for Soil Research, employing chemical concentration by 8-hydroxy-quinoline, tannic acid and thionalide. Complete delivery of the equipment is expected in the early months of 1952 and it should be in operation by the end of the year.

Also, orders have been placed for the electrical equipment to build a General Purpose Source Unit designed by A. Walsh and P. T. Beale of the British Non-Ferrous Metals Research Association. This unit, which can generate arc-like and spark-like discharges, gives an appreciably greater sensitivity with the more volatile elements, e.g., zinc.

For the relatively high potassium contents in plant materials, it is planned to use a direct reading device employing filters and a photocell which have been ordered for this purpose.

Advisory Work

In September, Mr. G. W. Lock and Mr. E. Diekmahns of the Tanganyika Sisal Growers' Association visited Muguga to discuss the organisation and equipment of a spectrochemical laboratory and full information was given to them. An assistant for that Organisation will receive training in the E.A.A.F.R.O. laboratories during 1952 prior to taking up his duties at Ngomeni, when the equipment arrives. Assistance will be given in setting up the equipment and putting it on a working basis.

Informal discussions have also been held about the possibility of giving similar help to the Uganda Department of Agriculture.

Publications:

Birch, H. F., (1951). "Relationship Between Base Saturation and Crop Response to Phosphate in Acid Soils." *Nature*, **168**, 388.

Birch, H. F., (1951). "The Relationship Between Phosphate Response and Base Saturation in Acid Soils." *J. Agric. Sci.* (in press).

Soil Physics

(Report by Dr. H. C. Pereira, Coffee Research Station, Department of Agriculture, Kenya)

Soil Structure Estimation

An understanding of the changes in soil, air and water relationships under tropical conditions of cultivation and cropping is a basic need for soil conservation and agricultural planning in East Africa. It is also of immediate practical importance for the advising of coffee planters on the treatment of their soils.

This subject has occupied the greater part of my time in 1951.

Core sampling and tension plate equipment purchased for the new Muguga laboratory has been used for a detailed practical study of the permeability and pore space distribution (in the main coffee soil type) and their relation to various techniques of soil sieving measurement. The work has been based on a comprehensive cultivation trial conducted jointly with the Agricultural Officer of the Coffee Services. Substantial progress can now be reported, and the apparatus and methods will be used at Muguga on other East African

soil types in 1952. Arrangements to study soil structure changes occurring on O.F.C. experiments at Kongwa have already been made.

Water Use by Forest Covers on the Aberdares

Exploratory observations, using the electrical resistance method, have continued under bamboo and cypress at Kinale. A start has been made on the measurement of the depth of soil profile from which water is drawn, by washing out the root systems of mature specimens of indigenous bamboo, plantation cypress (*C. macrocarpa*) and pine (*P. patula*). Pits were prepared by the Kenya Forest Department, who also provided fire-fighting equipment which proved most effective for root washing. The three root-systems were photographed and the following tentative conclusions were drawn:—

Bamboo — can draw on all available soil moisture from the first twelve feet of soil, and on some of the moisture as far as the seventeen feet excavated.

Cypress (*C. macrocarpa*) — can draw on all available soil moisture in the first six feet and on some of the available moisture to a depth of sixteen feet. No roots were observed below sixteen feet on this site.

Pine (*P. patula*) — can draw on all available moisture from the first fourteen feet, and to some extent down to and even below the eighteen feet examined.

These preliminary studies, which need much further replication, and the results from the gypsum blocks, indicate that measurements of soil moisture changes in the root range, together with the interception measurements made by the Kenya Forest Department, will be able to reveal major differences in the water use by different forest covers. This study will, of necessity, be both strenuous and time-consuming.

Relation of Meteorological Data to Water Use by Kikuyu Grass

The catchment area experiment at Tigoni, initiated by the P.W.D. with my assistance in 1949, and handed over to E.A.A.F.R.O., in 1950, was continued on a reduced scale for staff reasons. Observations of rainfall, run-off, the soil moisture changes indicated by gypsum blocks, air temperature, windspeed and humidity were continued. No suitable radiation instrument was available, and a Campbell-Stokes sunshine recorder, lent by the East African Meteorological Department, was set up to give some estimate of incoming radiation. Even the very heavy rainfall of 1951 produced no run-off from this steep-sided grass basin of eleven acres.

Soil Moisture and Structure Studies at Kongwa

Arrangements were worked out during a visit for a combined field and laboratory study of the moisture conservation aspects of both fallow and two-year rotation practices at Kongwa. By courtesy of the Senior Entomologist (Coffee), Mr. R. A. Wood, of the O.F.C. Scientific Staff, subsequently spent some six weeks at the Coffee Research Station to learn techniques of the preparation and use of gypsum blocks for soil moisture study, and the use of core sampling and root washing equipment.

Liaison Visits

In December a visit was made to Uganda where, on behalf of E.A.A.F.R.O., two days were spent at Namulonge discussing soil physics and meteorology measurements with the Cotton Research staff, followed by two days at Kawanda, where problems of the interaction of mulching and soil nitrogen were studied on behalf of the Coffee Research Station.

Soil Survey

STAFF

G. H. Gethin Jones ..... *Soil Surveyor*

Mr. Gethin Jones was transferred at the end of 1950 from the post of Senior Soil Chemist, Kenya Department of Agriculture, to take charge of the new Soil Survey Section E.A.A.F.R.O. Unfortunately it was not possible to provide any assistant staff during 1951.

Considerable time was, therefore, devoted to collecting and sorting out pedological data obtained from records and during reconnaissance tours for the purpose of finding out to what extent low category Soil Series noted in one part of East Africa are replicated in another part, perhaps a thousand miles distant. A study has been made of the soils that have been derived from similar parent material under different environmental conditions and again from different lithological materials under a similar environment. It was noted that though in many instances conditions which could be classed within the range of a Soil Series occur throughout East Africa, there is a marked shift in the proportions of such similar soils depending much on the particular history of the land surface. As one travelled through new regions more and more new sets of soil conditions were noted.

The great variety of climate from moist and dry tropics to cold and humid conditions, combined with varied geology and past and present land forms have, over a region of some two-thirds of a million square miles, given rise to a vast number of different combinations of soil characteristics or natural soil classes. Over large areas the present soils are relics of past climates, and elsewhere specific physiographic and biotic factors have had much influence on soil formation. From the study of soil variations found over limited scattered regions it is likely that the final classification of East Africa soils at about the arbitrary Series level will need to accommodate something of the order of a thousand separate units.

There is a definite need for a specific system of classification that can be progressively developed and extended so as to contain a very large number of different soil types. As the survey proceeds, some soils would be readily classified, but there will also be a mass of records on the genesis, constitution and the main morphological characters of new sets of soil conditions that will be classed and named when the several descriptions are found to be sufficiently representative and widespread. For the evolution of a systematic

method of classification, there will be need for a higher category at about the level of the Soil Association or Fasc to accommodate several not greatly dissimilar Soil Series that are parallel in their morphology. Again, the similar grouping of companion units of this intermediate category will give the Great Soil Groups with common main properties.

On ancient plateaux and low-lying plains the stage of peneplanation or new dissection is reflected in characteristic catenary conditions which will greatly aid early soil survey. In such regions, which incidentally are often little developed, the usual detailed soil survey would not be practicable and classification will have to be in the form of sorting out the different catenary conditions, and detailed mapping will be confined to a series of narrow traverses across the physiographic soil sequences so that the whole can be described and mapped in terms of sets of conditions.

An appraisal of the task ahead has shown that during the early years of the survey, when soil surveyors are also receiving further training, there will be need to have tentative classifications at the different levels while a more permanent system that is best able to accommodate a great number of new sets of conditions is being worked out. This in itself necessitates detailed field soil survey and the mapping of chosen small representative areas so as to ascertain the kinds of soil that exist and also their relative geographical association. The detailed complete sheet by sheet survey will have to be postponed until there is an adequate basis for the framework of classification. This procedure also has the merits that in the early years some information will be available for much larger portions of East Africa that would be the case if survey is concentrated over the relatively small areas.

In general, it is planned to survey and map at the Soil Association of Fasc level by means of traverse lines, aided by air photos where there is proved correlation, and the further assessment of such regions by partial more detailed survey at the Series level. The latter representative areas would be scattered according to the heterogeneity and the pattern of soil distribution to give a 2% to 5% cover. Detailed survey will also be necessary in the study of catenary conditions. Apart from the main general surveys described above, complete detailed survey will be done in the case of particular development projects and of the sites of present and future experimental work.

While carrying out the above soil survey, studies will be made of soil genesis and classification at the Great Soil Group level so as to revise and fill in the gaps in Milne's (1934) Soil Map of East Africa. Little specific information is known of the Soil Groups already listed and it has already become apparent that many new Soil Groups occur in East Africa.

Reconnaissance Soil Surveys

During the year six reconnaissance soil survey tours were made in East Africa and Nyasaland. Three of these tours were made by the request and at the expense of the Overseas Food Corporation, the Central Africa Rail Link (Survey Development) and the

Nyasaland Government. Those in Uganda and Tanganyika were made mainly with the aim of correlating work with the local soil specialists and for the purpose of co-ordinating suggested land-use surveys with the Departments of Agriculture. In Uganda a rapid road tour of some 2,000 miles was made through portions of the Eastern and Northern Provinces and the Bunyoro and Mengo Districts with Dr. Chenery, the Senior Chemist, and Mr. Trapnell, Officer-in-Charge of the Ecological Training Scheme, when soil and ecological problems were discussed. In Tanganyika short tours were made with Mr. Calton, the Government Chemist. A visit was also made to Zanzibar to study the soil survey work already done there by Mr. Calton.

Land-use Surveys

Discussions were held with the territorial Directors of Agriculture to discuss the possibilities of co-ordinating land-use or land potentiality surveys by suitable territorial officers. Such a survey working ahead of the slower systematic soil survey would denote other surface features than the approximate boundaries of soil main types and, together with the accompanying agronomic reports, would give useful information on land potentiality needed for planned development. This work would also conserve useful data already known to departmental officers which would otherwise be lost when they leave their districts. Relevant items would be the natural vegetation where it is well-defined, topography, drainage, the degree and extent of accelerated soil erosion; harmful over-cultivation, overgrazing, bush or grass fires; the scarcity of water supplies, fuel and of suitable land itself for the subsistence of the population. The maps could also indicate suitable areas which are at present underdeveloped. There would be need for a certain amount of standardisation of mapping and it was suggested that the co-ordination of this kind of land-use survey be one of the duties of a proposed East Africa Soil Survey Committee and that the work be done under the immediate guidance of the territorial soil specialist.

In Tanganyika it was arranged that the Agricultural Officer, Lindi, should start a trial survey in the Mnacho District bordering on the Overseas Food Corporation lands. A sample area of some 40 square miles which had been surveyed on a scale of 1:50,000 was later examined near Nachingwea. There had been a correct approach to soil classification. However, too much reliance had been placed on air photos, without adequate ground control, in delineating soil boundaries and more useful data about surface features could have been recorded. A feature of the accompanying report was a frequent marked correlation between particular soils and the natural vegetation and also the present system of land-use. This type of survey is being continued in the Lake Province.

In Uganda also land-use surveys had long been anticipated. Emphasis was laid on the desirability of a joint soil and ecological survey to guide many projected developments involving agriculture, veterinary work, industry and communications. It was agreed that two experienced Agricultural Officers should, as an experiment, prepare first land-use maps of their districts. In Kenya, trial land-use surveys were to be started in the Highlands.

At the request of the Project Manager of the Central African Rail Link (Development Survey) a reconnaissance was made with the Survey Party over the country served by some 150 miles of the projected new railway alignment between the Mbozi Plateau and the head waters of the Kilombero River. The different kinds of soil noted in the several geographical districts have been described, together with an assessment of their agricultural potentialities. Over a region with very diverse kinds of soils, it is interesting to note how the age of the land surface and the pedogenic processes to which the soils had been subjected were often the dominant factors in governing present soil fertility. Thus, areas with youthful volcanic soils are the most fertile and the most densely populated, whereas ancient, upland soils derived from basement complex rocks under rain forest, without much geological erosion but recently subjected to a period of cultivation, are highly leached and of low inherent fertility. The better soils with adequate rainfall and water supplies are already settled by African cultivators and in such regions development must mainly depend on better husbandry methods and the organised production of a wide range of crops. Over most of the region surveyed, development has been limited by inadequate and erratic rainfall and more especially of "effective" rainfall for reliable crop production. In the case of the marginal zones there is need to obtain sound data about the particular soil treatments that will absorb the maximum amount of rainfall and hold this against rapid surface and sub-surface evaporation. With such information and the development of more drought-resistant strains of crops, it should be possible to have large-scale mechanised farming on lands now used only for cattle ranching.

The greatest scope for a relatively rapid increase in production, more especially of surplus crops for export, is by making the maximum use of available water supplies for irrigation purposes. This survey showed possibilities of such developments along the southern portion of the Usango Plain bordering on the Poroto Mountains and the Kipengeri Range. There is a clear need for a detailed survey of the land and water resources, taking note of the possibilities of an integrated major scheme involving the storage of flood waters, whereby water and land resources are considered as a whole. The prospects are promising.

Examination was also made of the soil survey work done over representative portions of some three million acres mapped by the O.F.C. field staff at Nachingwea in the Southern Province of Tanganyika. The classification, or rather the listing of the soils, had been based on a combination of certain soil properties and the vegetation. The present cover had been taken as an important factor in the classification itself rather than as a phase for the further qualification of natural soil characteristics. The knowledge of the distribution of the vegetation was useful in assessing the ease of clearing, but as the cover has been greatly influenced by past cultivation and fire, its use as a basis for mapping has reduced the permanent value of the survey. Mr. C. F. Charters in his valuable Report (1950) makes the same comment. In consequence, it has now

been arranged that further survey work and certain other related soil investigations bearing on future developments be co-ordinated with the Soil Survey Section of E.A.A.F.R.O.

A visit was made to Nyasaland to advise on the scope and technique of soil survey necessary in connection with the inclusion of irrigation in the Shire Valley Development Project of lake stabilisation, power development and flood control. A reconnaissance of the valley from the southern end of Lake Nyasa to Chiromo showed that there was ample land with suitable topography and soil conditions for major irrigation schemes, both above and below the middle section of hilly broken country. A sequence of soil surveys was advised, each covering lesser amounts of land in greater detail. There would be a preliminary reconnaissance survey based on traverses of all likely lands within the Shire catchment area as a whole, thus including possible upland sites adjoining tributary rivers as well as on the floor of the valley. Following a study of a factual account of the physical possibilities and the relative merits of the general soil conditions, the economy of delivering water supplies and also the agronomic and social factors, those in authority would advise particular sites for further surveys. These would take the form of detailed reconnaissance surveys at two scales of mapping. There would be complete soil surveys of the commanded areas by traverses and necessary offsets based on the 1:50,000 maps and the parent air photos, and also more detailed surveys of small areas with representative soil conditions on a scale of 1:5,000. This latter survey would take special note of soil properties relating to crops under irrigation and would give the likely range of conditions and their extent within the larger mapped units. Based on this work, the soil surveyor who is experienced in irrigation requirements would prepare secondary maps allotting grades of general suitability for cropping under irrigation, and also give estimates of the extent of lands under the several arbitrary grades that occur. With this information, together with hydraulic and agronomic reports, it would be possible to decide on the location and extent of the most meritorious irrigation schemes. The cost of the soil survey up to this last stage was estimated to be £10,500. There would then be need for detailed irrigation soil surveys and pilot schemes. All the recommendations in the Report were accepted by the Nyasaland Government.

It has been arranged that soil survey work in Nyasaland be co-ordinated with the Soil Survey Section of E.A.A.F.R.O. and towards this end a new member of the staff spent three weeks at Muguga on his way to the Protectorate.

A provisional soil map, based on field characteristics only, on a scale of 1:5,000 has been prepared for the E.A.A.F.R.O. estate; it will be used in planning the development of the farming area. The soil distribution is largely governed by the presence of drainage fissures in the underlying Limuru Trachyte rock, such that the elevated areas with mainly sedentary soils are separated by dry depressions with deep accumulations of "creep" soils. An interesting associated phenomenon is the formation of very deep cracks reaching up to the land surface, resulting from the collapse of segments of soil and sub-soil into underlying rock fissures.

Statistics

STAFF

P. Robinson ..... *Statistician*

The analysis of fertiliser experiments was again a major part of the work done by the section, and work continued on the co-ordination of the field data with the laboratory analysis of the soils, but, owing to limited library facilities during the transfer from Amani, progress was rather slow. Results obtained from phosphate applications to wheat and maize during the three years of the Kenya Highlands Fertiliser Scheme were consistent with the hypothesis put forward in last year's Report (p. 51) but more work needs to be done with the other nutrients.

Grassland research which was mentioned in last year's report has recently come to the fore again and a profitable visit to the Research Station at Ol-Joro-Orok was arranged. Little experimental work has so far been done on pasture in East Africa and the initial stages are, therefore, necessarily exploratory. The techniques used in other countries must first be studied and then applied to East African conditions.

Investigations on another comparatively new problem in East Africa were also started during the year. Pyrethrum is exported mainly to the United States and transport losses are quite appreciable. The samples taken to determine these losses, however, have shown inexplicable discrepancies and it is now evident that an examination of the sampling technique is necessary. Investigations have recently been started.

Experiments testing pyrethrum powder and other insecticides have also been examined; and experiments using herbicides have been designed. Where the herbicide is used for a plant like Sodom apple, the collection and examination of data is reasonably simple, but when used for plants of ramifying habit like couch grass the measurement of the effect is rather more difficult.

Variety trials carried out at Njoro have been analysed, and experiments with cassava examined. It does not seem out of place here, to record that it is not advisable to experiment with cassava using several dates of harvesting in one experiment.

Throughout many of the experiments examined in the Statistical Section it has been obvious that climate in general and rainfall in particular have very great influences on many of the observed results. This does not apply only to crops but also to fungus attacks and insect activity. It is obvious, therefore, that an examination of meteorological data from the agricultural viewpoint should be most profitable.

In conjunction with the Plant Physiologist a method has been devised for the estimation of a predicted range of rainfall for monthly periods up to a year in advance. This has been applied to a wet area — Amani with a yearly average of 75″, and to a "medium" area — Kabete with a yearly average of 37.5″. A very reasonable agreement with actual falls has been found so far. It is

rather more difficult in dry areas to determine an expected monthly rainfall, but seasonal falls are somewhat easier to predict. With certain minor improvements in the method it should be possible to advise with some degree of certainty, whether the season is likely to be comparatively wet or comparatively dry, so that the farmer could be helped in practical questions such as deciding whether a short growing sorghum or a longer term crop should be grown in that particular season.

A paper dealing with the measurement of the reliability of rainfall in marginal areas is being prepared for publication. In addition to this, work has been proceeding on mapping the reliability of rainfall in the three East African territories. The data from some 700 suitable stations have already been used to prepare draft maps of the reliability of annual falls above 20″ and 30″ a year. Because of the enormous mass of data involved, work on the reliability of seasonal totals, which is of greater importance, will be somewhat slow.

Joint Division of Animal Industry

Staff

H. P. Ledger ..... *Farm Manager*

Clearing and Planting, 1951

The work of clearing the farm area, most of which had been under wattle plantations, together with that of the erection of the perimeter fence commenced in January, 1951. By the end of the year six miles of the perimeter fence had been erected at an average cost of Shs. 1,831.07 per mile. It is a five-strand, barbed-wire fence, the strands being stapled to split-cedar posts which are set at fifteen feet intervals. The cost, based on prices at the time of purchase, was follows:—

	Shs.	cts.
Analysis of Fencing Costs per Mile:		
353 Cedar Posts @ Shs. 2/25 each	794	25
21 Rolls of Barbed Wire @ Shs. 42/50 per 440 yards	892	50
½ cwt. of Staples @ Shs. 101/- per cwt. ...	50	50
Cost of digging holes 23½ man days @ Shs. 1/66 per man day	49	00
Cost of lining up and setting posts 15 man days @ Shs. 1/66 per man day	24	90
Cost of erecting wire 12 man days @ Shs. 1/66 per man day	19	92
Total cost per mile Shs.	1,831	07

The first fifty acres to be cleared were in the vicinity of the future farm buildings and metabolism laboratory sites. Although the area, previously under wattle, was purported to have been clear felled and stumped in 1949, it was soon discovered that this claim applied only to the wattle crop and that old forest and bush stumps were widely scattered. A large proportion of the bigger stumps were the remains of cedar trees which had been felled close to the ground not less than ten years ago. These stumps proved to be as firmly fixed and as difficult to remove as they were on the day the trees were felled.

Several mechanical methods were tried for removing these recalcitrant stumps, including the use of a monkey winch, block and tackle in conjunction with a tractor, etc. The main difficulty encountered was that there was little or no part of the stump above the ground and a considerable amount of digging had to be done before a firm grip could be obtained. It took time to rig up the gear, fix suitable anchorages, etc., and this, combined with the time lost in repairing and renewing inevitable breakages, led to the conclusion that it was preferable to dig the roots out by hand and then tow the stumps away. Where three or more feet of the bole remained, or where a standing tree had to be removed and when normal farm machinery only was available, mechanical clearing proved a more feasible proposition in spite of the fact that many lateral roots had still to be removed by hand.

The cost of clearing and stumping ready for ploughing ranged from Shs. 91/52 per acre, on a 9-acre plot, with a large-stump density of 39.86 per acre to Shs. 40/13 per acre, on an 11-acre plot, with an average large-stump density of 4.72 per acre. These costings were based on labour receiving Shs. 40/- each per month, with no extras, and included the removal of all brash to the side of the block ready for burning. Normally the latter would not be carried out but was a necessary additional service at Muguga because the ash from the burning of brash, if left on the plots, would interfere with subsequent experimental work.

By the second week in March, 35 acres had been cleared and cultivated and though, due to the short time available for preparation, the resulting seed bed left much to be desired a series of observational plots of the undermentioned fodder crops and grasses were laid down in time for the long rains.

Selection of Crops

The selection of crops was largely governed by the seed available locally at the time of planting because forward buying had not been possible. One of the main objectives in planting the crops was to gain as much local knowledge as possible on their growth and on their suitability for larger acreages next year. The crops planted fell into the following groups:—

(a) *Green Fodder and Silage Crops.*—Kale (Marrowstem and Thousand-headed), Kavirondo Sorghum, Sweet or Edible Lupins, Maize, Oats (Lampton), Oats (Algerian Grey — for grain), Oats and Vetch Mixture, Maize and Lupin Mixture.

(b) *Root Crops.*—Mangel (Yellow Globe, Long Red and Half-Sugar varieties), Sugar Beet, Potatoes (Kerr's Pink), and Edible Cannas.

(c) *Grasses and Legumes.*—*Bothriochloa insculpta*, *Chloris gayana* (Rhodes Grass) (Nzoia and a broad-leafed variety received from Tanganyika), *Bromus marginatus* (Brome Grass), *Melinis minutiflora* (Molasses Grass), *Lolium italicum* (Italian Rye), *L. perenne* (Perennial Rye), *Dactylis glomerata* (Cocksfoot), *Crotalaria intermedia*, Lucerne (Hunter's River) and *Cenchrus ciliaris* (African Foxtail). In addition to the above introduced grasses, there is on the farm a very promising variety of *Cynodon dactylon* (Star Grass) which, unlike *Pennesetum clandestinum* (Kikuyu Grass), which also grows well here, has no rhizomes and may be more easily eradicated and, therefore, be better suited to alternate husbandry.

Observations on Crops Grown in 1951 Long Rains

It is obviously impossible to arrive at any conclusions on only one year's cropping, particularly when that year has been one of exceptional rainfall and rushed planting conditions. Nevertheless, the information obtained has been extremely valuable as an indicator of (i) those crops which would have a reasonable chance of success as first year crops; (ii) those which might be successful if suitable adjustments were made in planting dates, seed rates and soil conditions; (iii) those crops which would not be expected to do well at any time and which, if not discarded out of hand, should only be continued in small trial plots.

From the experience gained in 1951, it would appear that, under the first heading would come maize, (for silage only, as the Kenya white variety tried this year was much too slow maturing for grain production at Muguga), edible lupins, Lampton oats, Yellow Globe mangel, edible cannas, Kale (Marrowstem and Thousand-headed), oats and vetch mixture, maize and lupin mixture.

Of the grasses and fodder legumes planted, it is as yet difficult to differentiate between those which established themselves, since one of the main tests must be their resistance to drought. Whatever may be the final result, there is no doubt that, under 1951 conditions, *Bromus marginatus* excelled in the provision of early feed in quantity during the planting year. It has been suggested that this grass fails after two years of growth but, even if this criticism is substantiated, it would nevertheless appear to fill the role of Italian rye in temperate regions, viz., its inclusion in a seed mixture to provide early feed and act as a nurse crop whilst the more permanent, but slower maturing grasses are establishing themselves. *Bothriochloa insculpta*, Italian rye, Perennial rye and *Melinis minutiflora* also established themselves readily from seed, whilst *Chloris gayana* (Nzoia), Perennial rye and lucerne failed to do so in economic quantities.

Grass plots of one acre were planted and seed was undersown to maize. It was noticed that those grasses and legumes which were poorly developed in the initial stages improved rapidly once the maize was removed. This was particularly true of *Chloris gayana*.

It should be mentioned that in this first season after clearing, all crops, with the exception of the grasses, oats and lupins suffered considerable damage from cutworms during the latter part of April and early May.

Maize (Kenya White)

This crop received a considerable set-back from the cold and wet conditions which prevailed during the first three months of growth but, in spite of this, did much better than could have been expected. A total of 30 acres were planted, and 25 acres were turned into silage, whilst the remaining five acres were left for seed and yielded six bags of second grade maize per acre. It is estimated that there was a loss of at least 15% due to the wet weather which persisted throughout harvesting. It is obvious that at Muguga a more quickly maturing variety is required, if the maize is to be grown for its grain.

Maize and Lupin Mixture

A maize and edible lupin mixture was tested to see whether the inclusion of the lupins improved the value and nutritive ratio of maize silage. Lupins were chosen for the mixture as the seed is roughly the same size as that of maize and can be used in the two row maize planter, one tin being filled with maize and the other with lupin seed.

It was thought that the maize might smother out the lupins, but this did not prove to be the case. The lupins grew well and were ready for cutting for silage at the same time as the maize. Analysis of the resulting silage has not yet been completed and it is proposed to repeat this trial next year to compare the return in food value per acre with that of other silage crops.

Sugar Beet

This crop germinated well but produced very little root.

Mangel (Long Red)

Germination was good, though here again root development was poor. Some improvement in root development was noted at the end of the year.

Mangel (Yellow Globe)

This proved to be a very promising crop making good root development and having the advantage of being easy to harvest even in hard ground because the greater portion of the root forms above ground.

Mangel (Half-Sugar)

Good germination was obtained but the subsequent root development was very poor.

Kale (Marrowstem)

The seed germinated well and produced a good crop. It is being left *in situ* to see how far it will carry through the dry season.

Kale (Thousand-headed)

This variety of Kale has not done quite so well as the Marrowstem, but it is well worth trying again. The seed bed on this plot was very rough and may account for the inferior growth in comparison with the Marrowstem variety.

Lupins (Edible)

The lupin plants established themselves very well and were attacked by cutworms to a far less extent than the crops on the adjoining plots. This crop was kept for seed and yielded just under five bags to the acre.

Kavirondo Sorghum

As might be expected, this crop was not suited to the cold and wet conditions which existed in the early stages and consequently growth was very slow and patchy. The rate of growth improved considerably towards the end of the year and the crop was turned into silage which will be analysed. Further trial plots were planted for the short rains (see next Section).

It would appear that any of the leafier strains of sorghums are worthy of further attention as fodder crops because with such quick maturing plants there is the additional advantage that a ratoon crop can be taken, thus giving two crops from one planting. But much more must be learned of the time and of the conditions under which it can safely be fed to livestock in view of its alleged toxic properties.

Edible Cannas

The main object in planting this crop was to clean an area which was heavily infested with couch. It has proved a hardy crop which needs very little care and attention and can be easily cleaned. As it develops it forms a good smother crop and has the advantage that it can be left *in situ* as a dry season reserve fodder crop which can be used if other fodders are in short supply.

Oats and Vetch Mixture

This seed mixture was broadcast at the rate of 40 lbs. vetch and 80 lbs. of oats per acre and produced a very good crop for ensilage. At this rate of seeding the oats tended to crowd out the vetches and possibly 70 lbs. per acre of oats seed would prove more satisfactory. Lower seeding rates will be tested in 1952.

Oats (Lampton)

This variety of oats produced a good leafy crop which unfortunately suffered severely from leaf rust before it was sufficiently mature to make first class silage. It was cut when the first seed heads were emerging from their sheaths and the resulting silage will be analysed.

Oats (Algerian Grey)

It was intended to grow this variety of oats for grain collection but the results were disappointing. Like the Lampton oats this variety

suffered severely from leaf rust and such grain as was formed was very light, though very attractive to birds.

Potatoes (Kerr's Pink)

Ten bags of the Kerr's pink variety were planted and were most promising. Later, however, they were heavily infested with *Phytophthora infestans* (Potato Blight) the control of which by spraying with Bordeaux mixture, was largely nullified by the almost continuous rain which fell during the growing period. The very poor yield of six bags of ware potatoes and ten bags of chats stresses the need for trials designed to discover more effective means of controlling this pest.

Observations on Crops Grown in 1951 Short Rains

Following the planting of the long rain crops clearing was resumed and by the end of the year a further 170 acres had been cleared, of which six acres had been planted to buckwheat, four acres to haricot beans, four acres to Rose Coco beans, 70 acres to Canadian Wonder and two acres to Kavirondo Sorghum for the short rainy season.

The beans were planted in order to secure a cash crop during the short rains and, at the time of writing, look most promising. They were thickly planted in 14-inch rows to act as a smother crop but were not really satisfactory for this purpose. In their first month they acted as a good smother crop but, as soon as they began to dry off, the weeds regained supremacy. There was little to choose between the three varieties during their growing period and as harvesting had not commenced at the time of writing it is not possible to compare yields.

Buckwheat, which was grown as a trial crop, and was sown at the rate of 17 lbs. per acre in 14-inch rows, proved to be a first class smother crop on the better land.

The Kavirondo Sorghum which was sown for the short rains appears to be much better suited to the hotter and dryer weather conditions which prevailed during the latter half of December. It will provide a useful greenfodder crop for use during the dry season but, as mentioned earlier, its purported toxic properties will need close investigation.

Observation on Grasses Planted in 1951

Bothriochloa insculpta

The seed of this grass germinated very well and gave a much better stand than is normal at lower altitudes. It would appear to be a grass worth including in seed mixtures to give an early "bottom" to a new ley. It also has the great advantage that it does not pull out when grazed during the first dry season. It is a good seed producer and stocks can be built up reasonably quickly from a small plot.

Melinis minutiflora

This grass grew well from seed and gave a thick cover and a good yield of fodder in its first year. It is also a prolific seed producer though a considerable amount of care is necessary to avoid loss through shedding when the crop is ripe.

Bromus marginatus

For providing early feed, this grass proved the best of those planted this year. It had produced two cuts as well as abundant seed by the end of December. When sown in mixtures, five pounds of seed per acre would appear an ample seeding rate.

Lucerne (Hunter's River)

Very poor seed germination was obtained and the plants which germinated made very poor growth. It is possible that inoculation of the seed might have been beneficial, although some seed which was spilt at the side of the plot germinated and the plants grew well. There was no lack of water and other crops grown from the same batch of seed were reported to have done well. Two possible reasons for failure are that (a) the seed bed was insufficiently consolidated and (b) that lucerne is not suited to a maize cover crop.

Italian Rye Grass

A very good cover was obtained but its vegetative appearance was entirely different from that in the United Kingdom. At Muguga it has developed into firmly rooted tufts with its leaves wilted and lying prone. So far no seed has been produced. Although a good cover was obtained, it is doubtful whether the amount of fodder produced this year would justify its use.

Perennial Rye

The vegetative growth was similar to that of Italian rye grass, but the cover was poor and there were many large patches of bare soil on which a few scattered tufts were growing. Like the Italian rye grass, it has produced no seed.

Chloris gayana

Growth was very disappointing early in the season but, once the cover crop of maize had been removed, patches of the grass developed well. Whether the belated growth of the *Chloris* was due to the removal of the maize cover crop or the result of tardy germination, which is often a characteristic of this grass, will be investigated in subsequent years. Such patches as became established produced a good supply of seed, but the leaf tended to be on the small side.

Cocksfoot

Seed of this grass failed to germinate.

Crotalaria intermedia

No seeds germinated.

Cenchrus ciliaris

The seeds of this species failed to germinate but a further test will be made in 1952.

Grass Mixtures

In addition to the planting of the above grasses in pure stands, the following grass mixtures were tested:—

(a) Grass Seed Mixture I (Imported — Indigenous):

10 lb. Italian Rye Grass.
5 lb. Perennial Rye Grass.
10 lb. *Chloris gayana* (Nzoia).
5 lb. *Bromus marginatus.*

Total: 30 lb. an acre at a cost of Shs. 87/50 per acre.

This was an expensive seed mixture, although the total seed rate could probably have been reduced with advantage. The indigenous grasses developed to a greater extent than the exotics and, by the end of the year, the plot was virtually a *Bromus* pasture containing a fair amount of *Chloris* in patches together with scattered tufts of rye grass.

(b) Grass Seed Mixture II (Imported — Indigenous):

3½ lb. Cocksfoot.
5 lb. Perennial Rye Grass.
10 lb. *Chloris gayana* (Nzoia).
5 lb. *Bromus marginatus.*

Total: 23½ lb. per acre at a cost of Shs. 54/75 per acre.

The cocksfoot failed to germinate and the final appearance of the plot resembled that for Mixture I.

(c) Grass Seed Mixture III (Imported — Indigenous):

10 lb. *Chloris gayana*
4 lb. Cocksfoot.
5 lb. *Melinis minutiflora.*

Total: 19 lb. per acre at a cost of Shs. 64/25 per acre.

The cocksfoot again failed to germinate. The *Melinis* grew better than the Chloris and in patches developed into pure stands.

(d) Grass Seed Mixture IV (Indigenous):

10 lb. *Chloris gayana.*
5 lb. *Bromus marginatus*
5 lb. *Melinis minutiflora*

Total: 20 lb. per acre at a cost of Shs. 65/25 per acre.

This was undoubtedly the best mixture tested this year. *Bromus* and *Melinis* seed appeared to be in suitable proportions for Muguga, although a reduction in the amount of *Melinis* seed could possibly be made in order to reduce cost. An increase in the quantity of *Chloris gayana* seed would also probably improve the mixture.

Field Trials

Facilities were made available to two firms to carry out field trials for testing the efficiency of certain systemics in the eradication of *Digitaria scalarum* (couch grass) and *Solanum* spp. (Sodom apple).

Although these trials are not yet complete they have already shown the necessity to evolve a more satisfactory technique for the evaluation of the effectiveness of the different systemics used and of their efficiency at different rates and times of application.

In the *Digitaria scalarum* trials, in which both cultivated and uncultivated stands of the grass were sprayed with varying rates of the chemical, no killing was observed during a drought period which followed immediately after application, but shortly after the rains started there was a marked scorching and killing in all of the treated plots. Although differences between treated and control plots were obvious to the eye the variability between treated plots when scored by eye or by counting living and dead rhyzomes was such that it was impossible to measure the value of different rates of application. As a result of this preliminary trial improved methods of measuring the kill will be used in later tests.

The *Solanum* trials consisted of spraying mature and immature growths of the weed with varying rates of two chemical preparations. Here again kills were obtained on all treated plots but scoring will not be completed until after the 1952 long rains.

Buildings — Construction

The metabolism laboratory, farm office, Dutch barn and cattle dip were under construction at the end of the year and it hoped that the remaining farm buildings, comprising calf pens, loose boxes, pigsties, milking parlour and dairy will be completed during the first six months of 1952. It is hoped that stock will have been purchased by the time the buildings are completed and that the Animal Industry Division will then get into its stride.

ATTACHED C.D. & D. SCHEMES

Termite Research

Staff

W. V. Harris ..... *Officer-in-Charge*
Miss P. B. Kemp ..... *Research Officer*
W. A. Sands ..... *Research Officer*

Systematics

Special attention has been paid to the East African species of the genus *Odontotermes* in view of their importance in the soil fauna of many areas. Types were studied in the Naturhistoriska Riksmuseum, Stockholm, the Zoological Museum, Cambridge, and the British Museum (Natural History). Other genera in the collection have been dealt with as far as possible under local conditions.

Biology

Laboratory cultures have been established from alates of *Noditermes, Basidentitermes, Odontotermes* and *Microtermes* and observations made on early stages of colony formation. It was not found possible to induce pairing in *Coptotermes amanii* alates which were found emerging in the vicinity of the laboratory. Cultures of various Kalotermitidae have been established from nymphs and soldiers and these have proved of value in obtaining alates for systematic work. The wide variation in size of soldiers obtained in cultures of Kalotermitids is being studied in relation to the value of size as an aid to specific determination.

The ecological survey of the termites of north-eastern Tanganyika has continued. Trenches and traps of suitable timber have been employed to obtain both qualitative and quantitative data on subterranean species, while field collections of mound builders and aboreal species have been made in all the major vegetation zones. *Microtermes* and *Microcerotermes* are in general the most widely distributed genera. *Anoplotermes* has been found to be numerous in forest and woodland. The comparative scarcity of termites in the rain forests of the Eastern Usambaras, all below 4,000 feet above sea level, is unexpected. *Odontotermes* is considered the most abundant termite of the plains. The greatest variety is to be found in lowland thicket where the number of species has reached 30 in each of several localities. So far a total of 60 species has been recognised in the area under consideration.

Termite Control

A trial to test the efficiency of some proprietary wood preservatives, begun in Uganda in 1949, has now been concluded. Results have emphasised the necessity for proper methods of impregnation. Dipping timber slabs in the cold preservative for 30 minutes gave on the whole but poor protection, whereas a "hot and cold treatment" in which the timber is put in a hot solution and left there to cool over a period of some twelve hours gave satisfactory protection. Green *Eucalyptus* logs responded well to the "hot and cold treatment."

Zanzibar

Collecting in the island during August produced 20 species of termites belonging to 14 genera. Two out of the 10 species listed by Sjostedt were not found.

Out of the 22 species thus recorded from Zanzibar, only one is not now known from the adjacent mainland, and that is an *Odontotermes* described from the alates. Topotypes of *Amitermes unidentatus* Wasmann were obtained in quantity for distribution to other workers.

Termites are an obstacle to the replanting of cloves and other trees in parts of Zanzibar. Damage to the woodwork of dwellings is prevalent, though the use of imported hardwoods resistant to termites for the larger buildings has made the problem less acute there than in other coastal areas.

Aden

An extensive journey through the Aden Protectorate during November and December produced records of twelve species belonging to the genera *Kalotermes*, *Hodotermes*, *Psammotermes*, *Reticulitermes*, *Microcerotermes*, *Amitermes*, *Macrotermes* and *Trinervitermes*.

Considerable damage to the woodwork of buildings is done by *Reticulitermes* and *Microcerotermes*. Any question of control measures will be complicated by local custom in building with mud bricks and accepting the fact of a comparatively short life. As most of the timber used has to be imported, the use of factory-impregnated material that is really termite-proof seems to have possibilities.

Somaliland Protectorate

A brief visit to Hargeisa produced new records of *Kalotermes* from Acacia branches, and a *Microcerotermes* from the woodwork of government buildings.

Other Areas

Identifications have been made of specimens from St. Helena, Nigeria and the Sudan.

Publications:

Harris, W. V., (1951). "The Ubiquitous Termite." *E.A. Agric. J.* **17**, 60.
Harris, W. V. "Notes on Wood Preservatives for Termite Control." *Ibid* (in the press).
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Ecological Training Scheme

Staff

C. A. Trapnell ..... *Officer-in-Charge*

The purpose of the Ecological Training Scheme is the training of a number of suitably qualified men for ecological and land use survey work in the Colonies. The scheme is concerned with two main aspects of ecological work: (1) the study of natural vegetation types in relation to climate, soil and human factors, and their classification and mapping, and (2), the application of ecological methods, incorporating vegetation survey, to the investigation of land resources and of present and potential land usage. The initial phase of the scheme has been financed by an interim grant from the Colonial Development and Welfare Fund. Estimates for the working of a full Training Scheme over the period 1952-55 inclusive were prepared early in the year, and in June a visit was made to England for discussion with the Colonial Agricultural Research Committee and to arrange for preliminary training of post-graduates in England. The first two students are now being trained at the Departments of Agriculture and Forestry, Oxford, and are due to arrive in East Africa in September, 1952. In the meantime the ecological laboratories

have been completed and equipped for air photograph studies and mapping work and for the handling of field material.

Reconnaissance tours were postponed until after the official opening of the Station and the visit to England. In late June and early July a tour was made through central and north Uganda in company with Mr. G. H. Gethin Jones, and Dr. E. M. Chenery of the Agricultural Research Station, Kawanda, with a view to obtaining a preliminary idea of the soils and vegetation of this region. In the course of the tour visits were made to the Serere Agricultural Experiment Station, to mvule plantation trials at Opit and Abera, to the Budongo forest and to the Bunyoro Agricultural Development Scheme at Kigomba.

After returning to Kawanda the ecological training scheme and Uganda's needs in this respect were discussed with the Director of Agriculture at Entebbe and with members of the Experimental Committee at Kawanda. Discussions were also had with the Conservator and Senior Assistant Conservator of Forests at Entebbe and with Mr. H. C. Dawkins, Forest Ecologist.

From the latter part of July to the beginning of September, a tour was made in Tanganyika, proceeding via Arusha and Dodoma to Mbeya, with a view to co-operation with the Central African Rail Link Development Survey.

In connection with the work of the Survey at Mbeya a brief reconnaissance was made of the Southern Highlands, Njombe, and the low-lying Usangu area, in company with Mr. B. Gilchrist of the Tanganyika Forestry Department. These journeys provided a valuable opportunity of studying Milne's soil types in the field, together with Gillman's vegetation map of the Territory. From Mbeya a visit was made to Njakwa in the Mzimba District of Nyasaland in order to meet Mr. G. Jackson, Ecologist in the Agricultural Department there. This made possible a journey on to the newly opened-up Nyika Plateau (where pilot trials with temperate cereals have been initiated) and a visit to land reclamation work at Zombwe Experiment Station. Visits were also made to the Scientific Department of the Overseas Food Corporation at Kongwa, to Agricultural Headquarters and the Survey Division at Dar es Salaam and to Ilonga Experiment Station near Kilosa. The tour confirmed that the rail link zone in Tanganyika would offer an interesting field for future training work, although there would be no shortage of suitable working areas in other parts of the Territory.

A further visit to Uganda was made in mid-November with a view to gaining impressions of the south-western region between Kampala and Lake Edward, through which the new railway extension will pass. This region has been proposed as one in which early ecological survey would be desirable.

This tour was extended to Kabale, to see ecological investigations which have been made at Kackwekano by the Agricultural Officer-in-Charge, Mr. J. W. Purseglove. At Mbarara visits were made with Mr. J. Ford of the Tsetse and Trypanosomiasis Research Organisation

to areas of bush and fly encroachment where vegetation survey work is in progress. Kamenyamigo Farm was seen at Masaka and air cover of the rail zone was examined at Entebbe before proceeding to Kawanda. Helpful advice was received here on possible fields for training surveys (Acholi District east of Gulu being among those considered suitable) and a short visit was made to the Empire Cotton Growing Corporation's Station at Namulonge.

Touring in Kenya has so far been confined to reconnaissance in transit through Nyanza, with visits to Kerita and Kaptagat Forest Stations, but contact has been made with the various technical departments in Nairobi with a view to future work. An address on ecology and land use in Africa was given to the Conference of Science Teachers held in Nairobi in April.

Among official visitors, Mr. B. Steele, proceeding on first appointment as Botanist to the Tsetse Fly Survey in Nyasaland, was here during the first fortnight in October for consultations on ecological methods, and a request for similar assistance has been made by the Desert Locust Survey. It should be possible to meet requests for short courses of this nature when they can be combined with the current training programme.

Climatic Data in Relation to Agriculture

STAFF

A. Walter ..... *Officer-in-Charge*

As plant growth is largely controlled by soil moisture, and this in turn is affected by incoming radiation, the simple measurement of radiation is of great importance. A direct measurement would be prohibitively costly in staff and apparatus. An indirect measurement by using simpler meteorological elements, such as are observed in large numbers of climatological stations is an alternative, and the function of this research is to investigate the possibility.

Research into the relation between radiation and some function of temperature which can be derived from simple observations made in a normal Stevensons screen was continued during the year, authority having been obtained to analyse the Kew records on the same lines as those employed for the Kenya records. The reason for the extension of the enquiry to regions outside the tropics was to ascertain how far the results obtained from the Kenya records were influenced by the uniformity of climatic conditions in the tropics, especially in regard to the uniform seasonal duration of sunshine in the Equatorial belt as well as the small non-cyclic effect in the diurnal variation of temperature.

The regions covered by the East African Research Organisation extend from Lat. 8 S. to Lat. 5 N. and it was considered that whatever final relation is established between some function of temperature and incoming solar radiation it should be applicable to regions outside

the equatorial belt. Further, from the Kenya results it was apparent that, although very high correlation was established in the mean between the integral of the diurnal curve taken over the interval between sunrise and sunset, and total radiation, individual days showed considerable scatter at certain seasons and it was thought that the cause or causes of this scatter could be more thoroughly investigated if the variants — vapour pressure, duration of sunshine, and non-cyclic change — had a greater range than is experienced under tropical conditions.

The Kew records have accordingly been examined and the relevant data extracted. The temperature curves for four years have been measured to show the range of temperature due to radiation alone, after the elimination of the considerable non-cyclic change which is caused by incoming air-masses producing large temperature fluctuations from day to day. At the same time other factors likely to influence the effect of radiation on the diurnal temperature curve have been tabulated. There is a high correlation between the range of temperature and incoming radiation as was the case with the Kenya data, but scatter of individual days is large at certain seasons.

The relation between the range of temperature and the amplitudes of the first three terms of the harmonic expression for the diurnal temperature freed from the effect of non-cyclic change is practically identical at Kew and in Kenya and it appears probable that the diurnal curve of temperature due to radiation can be reproduced universally if the range is known.

There is no doubt that both in the Kenya results and in the Kew results there is considerable scatter in the daily values between the function of temperature represented by the integral giving the number of degree hours and radiation. Some of this has already been traced to varying vapour presures, but it is too early yet to decide definitely what form the function of temperature which most closely represents the incoming solar radiation will ultimately take.